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CALCIFICATION AND OSSIFICATION

I. Calcification in the Callus in Healing Fractures in Normal Rats *

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This and the following paper [27] present the results of histological observation of the progress of calcification in the healing of experimental fractures in rats. The observations have been made upon fractures in normal rats on adequate diets, and in rachitic rats subjected to various experimental procedures for the purpose of controlling calcification, and the correlation of this process in the fracture callus with the same process in other parts of the bone.

There is an extensive literature upon the microscopic anatomy of healing of both accidental and experimental fractures. Wieder [30] Bast, Sullivan and Geist [1], Blaisdell and Cowan [3], and Downs and McKeown [11] have described the healing process in animals maintained on adequate diets. In the past, studies of calcification have depended, as a rule, upon the staining reactions of decalcified tissues, or upon a combination of these and roentgenological techniques. Examples of the latter are Ham, Tisdall and Drake [19], Goisman and Compere [18], and Compere, Hamilton, and Dewar[8]. These methods, while adequate for study of the advanced stages of calcification, have not been reliable for observation of the details and time relationships of the earliest stages.

A new approach to the study of calcification in the callus, and more particularly of those phases of the phenomenon which have not been accessible by previous methods, has been made possible by the routine described by McLean and Bloom [24] for the sectioning and staining of undecalcified sections of bone. Since previous knowledge has been deficient

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concerning the earlier stages of calcification, and since the methods here employed are peculiarly adapted to their study, the chief emphasis in these papers is upon a detailed consideration of these earlier stages.

The authors have found that the relationship of calcification to the development of osseous tissue is the same in the callus of healing fractures as in other examples of osteogenesis. This idea is not new, but has resulted in the past in carrying over to consideration of the callus errors of observation and interpretation made originally upon growing bone. In textbooks of pathology [21] and in studies of bone repair [3, 12, 30] it is stated that the formation of calcified bone in the callus is preceded by the growth of osteoid. This study will show that the new osseous tissue is calcifiable when it is laid down, and that under optimum conditions a preliminary stage of uncalcified osteoid is not typical of bone formation in the callus.

METHODS

The observations in this and the following paper [27] are based upon microscopic studies of tissues prepared by five different routines. Routines 1 and 2 were used for all experiments; 3, 4, and 5 were employed in particular experiments which required special methods.

1. Tissues fixed in Zenker-formol were embedded in nitro-cellulose, decalcified, and cut serially at ten micra, stained in hematoxylin-eosin-azure II, or hematoxylin and eosin, and by the Mallory-azan method.

2. Tissues fixed in neutral formalin were embedded in nitro-cellulose, sectioned serially, and stained with silver nitrate, hematoxylin, and eosin, according to the routine described by McLean and Bloom [24].

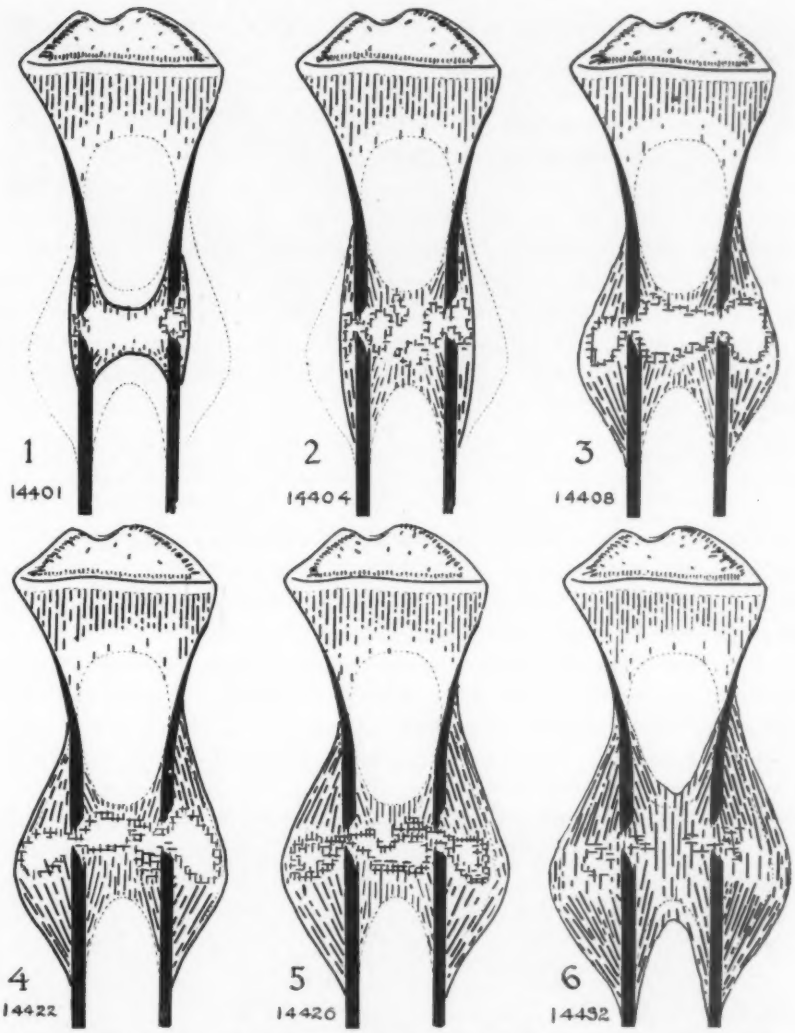
3. Frozen-dried tissue [14] (frozen in liquid air and dried in a vacuum at 30 degrees centigrade) infiltrated with 60-degree paraffin, were cut undecalcified at 15 to 20 micra, and impregnated (a) with 2-per-cent. silver nitrate followed by thorough washing and counterstaining in hematoxylin and eosin, or (b) with 40-per-cent. silver nitrate, and studied immediately after washing in water.

4. Unfixed, hand-cut sections were impregnated with 5-per-cent. silver nitrate, dehydrated in alcohol, and cleared in xylene.

5. Tissues stained supravitally with 2-per-cent. sodium alizarin sulphonate were fixed in neutral formalin, sectioned manually in 50-per-cent. alcohol, and cleared in isosafrol.

Fractures of the right tibia were prepared by destroying the continuity of the shaft about one centimeter under the secondary spongiosa. The technique consisted of grasping the right tibia between the tips of the index fingers and the thumbs and bending across the lateral diameter until the cortex snapped as would a glass tube. The cortex ends were replaced in a position as normal as possible. In most cases there was no laceration of the periosteum.

No attempt was made to immobilize the site of the injury or the animal.



Diagrammatic representation of deposits of bone salt in tibiae of growing rats, fractured at the age of forty-nine days. The rats had been fed on Bills' diet. Vertical hatching represents calcification of spongy bone, and cross hatching, calcified cartilage matrix. The light broken lines represent the usual limits of the epiphyseal cartilage, spongiosa, and fracture callus, respectively.

Fig. 1: two days after injury; Fig. 2: four days; Fig. 3: eight days; Fig. 4: twelve days; Fig. 5: eighteen days; and Fig. 6: union at twenty-four days.

EXPERIMENTAL

Fifteen litters of normal rats in addition to numerous individual normal rats given fractures as controls in other experiments, were used in these experiments. All were weaned at the age of twenty-one days to Bills' [2] stock diet. At seven weeks the right tibiae were fractured and allowed to heal for varying periods of time. Included within the series were healing fractures fixed at four-hour intervals during the first day, at

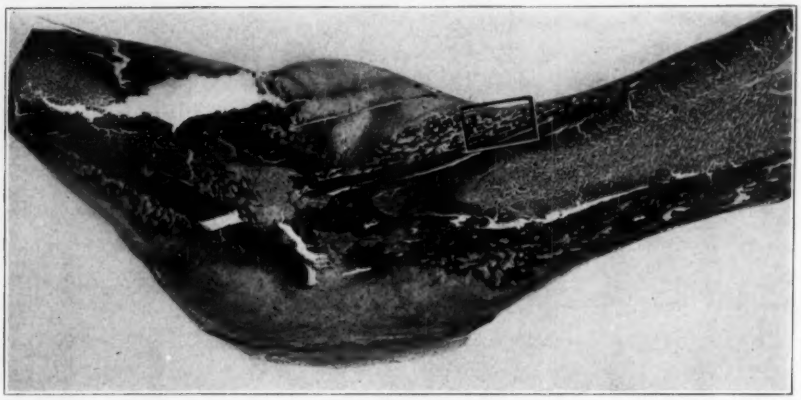


FIG. 7

Photomicrograph (× 8) of longitudinal section through fracture of undecalcified tibia of rat after six days of healing. Subperiosteal and subendosteal new bone are in contact with fibrocartilaginous callus, which is everywhere uncalcified except at points of contact with new bone. Rectangle indicates area of Fig. 8. (Silver nitrate hematoxylin eosin was the stain used for all sections illustrated.)

twelve-hour intervals during the second day, and at daily intervals thereafter until the twenty-eighth day.

The typical course of the healing of such fractures, considerably oversimplified, is illustrated diagrammatically in Figures 1 to 6, and may be briefly summarized here. The first reaction to the injury is essentially a sterile inflammation, which is the consequence of trauma and hemorrhage.

FIG. 8

Photomicrograph (× 94) of section through new bone originating from periosteum, from area indicated by rectangle in Fig. 7. *Po* indicates periosteum, and *Sh*, shaft. Early, granular calcification in the process of the formation of bone in contact with the periosteum is seen. The remainder of the bone, including the shaft, is fully calcified, without osteoid borders.

At four to eight hours after the bone is broken the defect is filled and surrounded by extravasated blood, hemorrhagic débris, and inflammatory exudate, including leukocytes. At twenty-four hours there is reparative new formation of connective tissue, which is at first ordinary granulation tissue, in the sense of Marchand [23], but which continues to proliferate, and to form dense fibrous connective tissue. A part of this differentiates further to form hyaline cartilage and fibrocartilage, and a part remains undifferentiated. The new tissue as a whole is here called the fibrocartilaginous callus.

At the same time that these changes are taking place in and near the defect in the bone, formation of new bone begins under the periosteum and endosteum, at some distance from the fracture line. This new bone invades and replaces the fibrocartilaginous callus, and leads to bony union at about the twenty-fourth day. Whether or not cells arising from the ordinary connective tissue of the callus have osteogenic potencies, cells arising from the deep or cambium layer of the periosteum, and from the endosteum, play the greater part in the production of new bone. Repair of fractures depends upon a variety of cells and of reparative processes, with, as will be seen, considerable variation in detail in the manner in which calcified bone is produced. The process as a whole is an excellent example of *organization* of diverse means to a common end,—in this case the healing of the fracture by bony union.

The Procallus

The procallus of an injured bone, as described by many writers [3] is now recognized by most investigators as identical with the inflammatory and early growth reactions to injury elsewhere in the body [26]. There have, however, been suggestions [20] that a "local calcium excess" in the early callus stimulates osteogenesis, which implies that deposition of the bone salt precedes rather than follows formation of bone.

Undecalcified sections of twenty-four-hour to forty-eight-hour fractures in normal young animals, stained with silver nitrate, fail to disclose deposition of bone salt in the inflammatory tissue. The initial blood clot is replaced by granulation tissue by the third day after the injury, and without hyalinization or calcification of any of the fibrin or hemorrhagic débris. The procallus thus becomes the fibrous callus.

Ossification

Once the initial inflammatory reaction to the injury is completed, resulting in the formation of a fibrocartilaginous mass in and around the defect in the bone, the essential process is the invasion of this mass from without by osteogenic tissue, and its replacement by bone. The picture is complicated by changes which occur within the callus prior to its invasion by bone, and by numerous variations in the detail of the invasion process.

Ossification begins at some distance from the fracture line, where there is a relatively slight primary reaction to the injury. Here the pic-

ture of the first step leading to bridging the fracture defect with new bone is that of uncomplicated intramembranous bone formation, originating from the deep layers of the periosteum and endosteum, and forming a collar of new bone around and within the shaft (Fig. 7). This new bone elevates the periosteum and endosteum, and forms a new growth which is wedge-shaped in longitudinal section, with the thin edge of the wedge farthest removed from the line of fracture. The new growth of bone reaches the callus, which by this time has undergone internal changes, invades it, and eventually replaces it with spongy bone.

So far this is a conventional description of the healing of a fracture. At this point, however, it must be emphasized that the intramembranous bone just described *is calcified as it is laid down*, and that under optimum conditions for the repair of bone is not seen as uncalcified osteoid (Figs. 8, 9, 10, and 11). There is first formed a fibrillar interstitial substance between the cytoplasmic processes of osteoblasts proliferating from the deep layers of the periosteum and endosteum. When first seen these fibers are rather loosely arranged in bundles, and may be slightly basophile. They are quickly transformed into a dense acidophile and homogeneous-appearing substance, in the meshes of which the cells with their communicating processes remain. At this stage the cells are bone cells, or osteocytes, and the interstitial substance is bone matrix. Calcification begins while the collagenous fibers are still loosely arranged, and before they have assumed the homogeneous appearance characteristic of bone matrix. The bone salt is usually seen first as isolated granules, the trabeculae later becoming uniformly calcified (Fig. 9).

A delay in calcification may occur. In addition to the many instances in which we have demonstrated calcification beginning simultaneously with the deposition of bone matrix, we have seen a number of animals in which in some areas of the callus there was a stage of uncalcified osteoid tissue, which later became calcified. On the basis of the histological findings, this was almost to be classified as a minimal form of rickets. These findings could not be correlated with the diet, as littermates receiving the same diet did not display osteoid, and none of the animals showed other signs of rickets. As will appear later in this paper, we attribute this sporadically occurring lag in calcification to an insufficient local supply of bone minerals, rather than to lack of calcifiability in the matrix.

The size and structure of the callus which has replaced the procallus at and near the site of injury and the amount of cartilage included within the callus depend, to a large degree, upon the extent of the initial injury, and upon the amount of trauma to which the site of the fracture is subsequently exposed [28, 30]. Glücksmann [17] has shown *in vitro* that pressure and tension stresses contribute to chondrogenesis. Young animals develop more abundant cartilage than older animals [6]. Rats develop more cartilage in the callus than do guinea pigs with identical injuries. We found cartilage in the callus in each of more than 400 rats with fractures of the tibia, and in several litters of rats with fractured ribs. In our experiments the fragments of the tibia were not immobilized, and no at-

tempt was made to control the activity of the animals; consequently callus formation, including formation of cartilage, may be assumed to have been at a maximum.

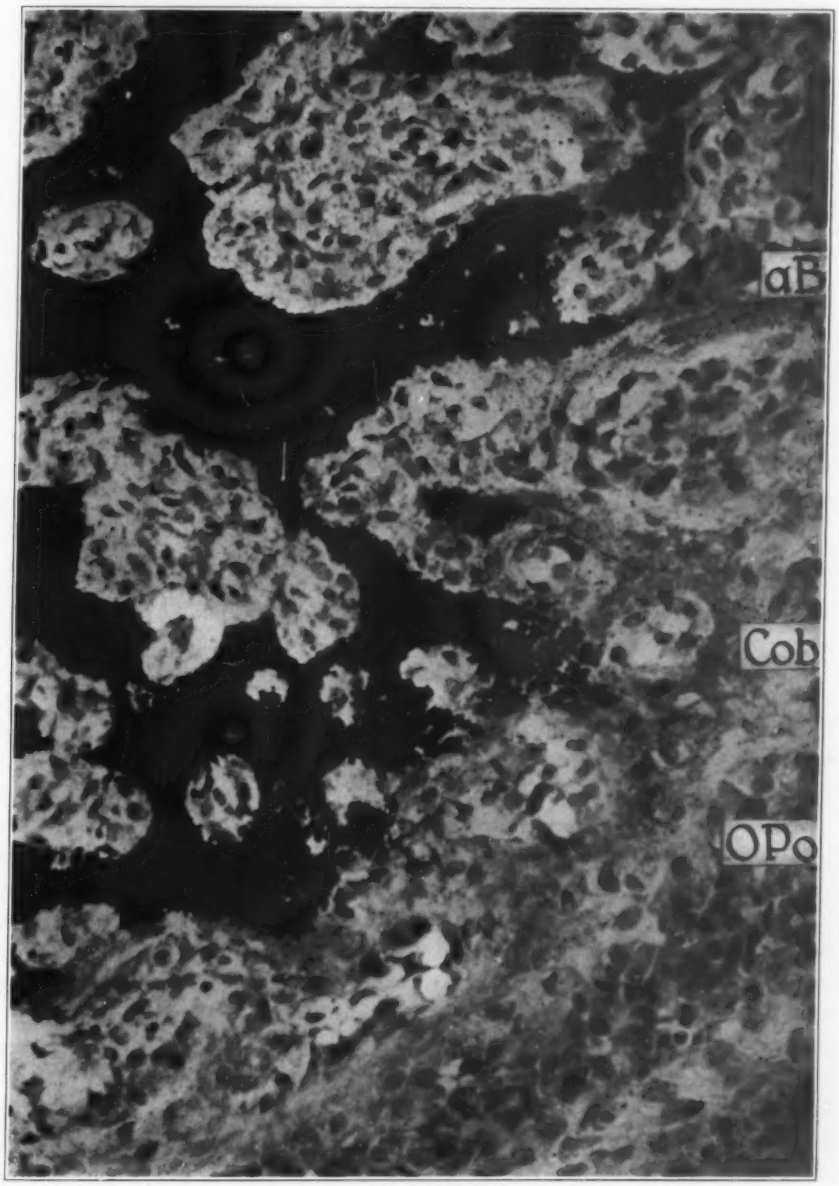


FIG. 9

Photomicrograph (× 390) of tangential section through the junction of the periosteum with bone, in an area similar to that shown in Fig. 8, after eight days of healing of a fracture of the tibia in a rat. *OPo* indicates the osteogenic layer of the periosteum; *Cob*, the zone in which new bone matrix, (*aB*) is being formed; *aB*, radiating bundles of collagenous fibers in process of formation and of calcification of subperiosteal bone. There has probably been a small amount of leaching of bone salt from lightly calcified matrix in zone *Cob*.

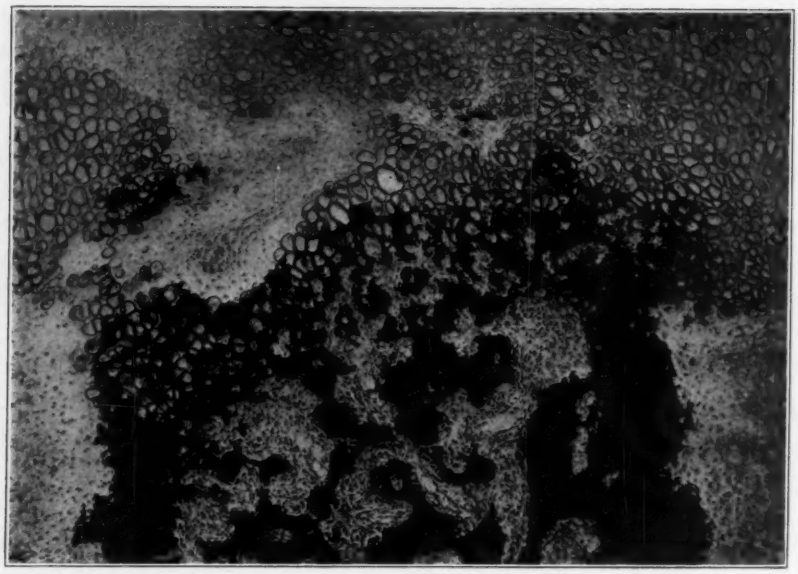


FIG. 10

Photomicrograph (× 80) of section through fibrocartilaginous callus in tibia of rat, after ten days of healing, shows invasion of hypertrophic cartilage by new subperiosteal bone. In this instance, which is exceptional, the process closely resembles that of intracartilaginous ossification in the embryo and in the growth of long bones. Cartilage is calcified in advance of invading bone, and there are suggestions of a primary spongiosa. There are no osteoid borders on the bone.

Cartilage appears in the callus from the second to the fourth day following the injury, by which time subperiosteal and subendosteal bone formation have begun, but may be at some distance from the fibrous mass. Small cartilage cells, comparable to the row-mother cells [9] of the epiphyseal cartilage appear within the mass of fibrous tissue. They arise in the fibrous connective tissue of the callus, undergo frequent mitosis, and produce cells which form nodular masses of hyaline cartilage. The nodules increase in size, and in part coalesce. Each nodule contains cells in various stages of development, with the more fully grown cartilage cells arranged generally toward the periphery of the nodules. Owing to the fusion of individual nodules, sections through the mass as a whole include cells in all stages of development, with the arrangement of the cells within the nodules obscured. In the final stages of development the cells increase in size, the cytoplasm becomes vesicular, and the nuclear chromatin is reduced in amount. In this stage they resemble the cells of the calcifying embryonic cartilage, and the cells of the zone of provisional calcification of the epiphyseal cartilage (Fig. 10). They are referred to as fully grown [10], hypertrophic [13], or vesicular [29].

When the new bone advancing from the periosteum and endosteum reaches and surrounds the fibrocartilaginous callus, the latter consists of a mass of dense tissue, composed in part of undifferentiated connective tissue, in part of fibrocartilage, and in part of the hyaline cartilage just described. Invasion of all these tissues occurs simultaneously, and ad-

FIG. 11

Photomicrograph (× 44) of section through periosteum and fibrocartilaginous callus in the tibia of a rat, after ten days of healing of fracture, shows invasion of hyaline cartilage and of fibrocartilage by new subperiosteal bone. *Po*, indicates periosteum; *fC*, fibrocartilage. Immature hyaline cartilage is being removed and replaced by bone, by the same process as that in removal of fibrocartilage. In some areas calcification of cartilage matrix precedes replacement by bone, but along a wide front immature hyaline cartilage in the process of removal is calcified only very superficially. No osteoid borders on bone are seen.

vances centripetally from the periphery of the callus. The general character of the process of invasion is essentially the same for the different types of tissues to be replaced by bone, though there is considerable variation in detail (Figs. 10 and 11).

In general the character of the invasion is that of intramembranous bone formation, but differs from the uncomplicated process just described by the fact that here a considerable amount of tissue has to be resorbed. The bone matrix formed by the invading osteogenic cells frequently incorporates cells of the fibrous tissue or of the fibrocartilage, and utilizes them as a framework for the formation of trabeculae of spongy bone. The intervening tissue is resorbed and replaced by blood vessels and the primitive marrow associated with osteogenesis. The newly formed bone matrix is calcifiable as soon as it is formed, and begins to calcify at once. There is, however, no random calcification of fibrous tissue, or of fibrocartilage as such. The great mass of the tissue remains at first uncalcified, and is involved in the calcification process only as bone advances into it.

Where hyaline cartilage is encountered by the invading tissue, the general process of invasion is the same as that just described,—that is, there is new formaton of spongy bone upon a framework of persisting cartilage, with removal of the intervening tissue. To a variable extent this process resembles that of the intracartilaginous ossification seen in the

embryo and in the subsequent growth of the long bones (Fig. 10). Usually, however, the process differs from the typical form, in that the invading capillaries and osteogenic cells are not guided into single rows of cartilage cells separated by calcified cartilage matrix. Nor is replacement of the cartilage by bone dependent upon calcification of the cartilage matrix, since it affects both calcified and uncalcified cartilage. In the latter case calcification occurs with the transition from cartilage to bone matrix, just as in the case of the fibrous and fibrocartilaginous tissues above described (Fig. 11).

Except where the callus is in contact with the cambium layer of the periosteum, calcification of the cartilage matrix does not occur until the advancing osteogenic tissues communicate with the nodular masses of cartilage. Whether it occurs then depends upon the state of the cartilage cells. If they have reached the state of fully grown or hypertrophic cells, a calcifiable matrix has been produced, and calcification will extend into the cartilage mass for a distance of several cells ahead of the advancing bone (Fig. 10). Owing, however, to the irregularities in the distribution of hypertrophic cells, which result from the coalescence of many nodules of cartilage, calcification of the cartilage matrix, in relation to the advancing bone, is much more irregular than is the orderly process of the intracartilaginous growth of the length of the long bones. Removal of cartilage is usually over a front of several cartilage cells at a time, similar to the process in rickets (Fig. 11).

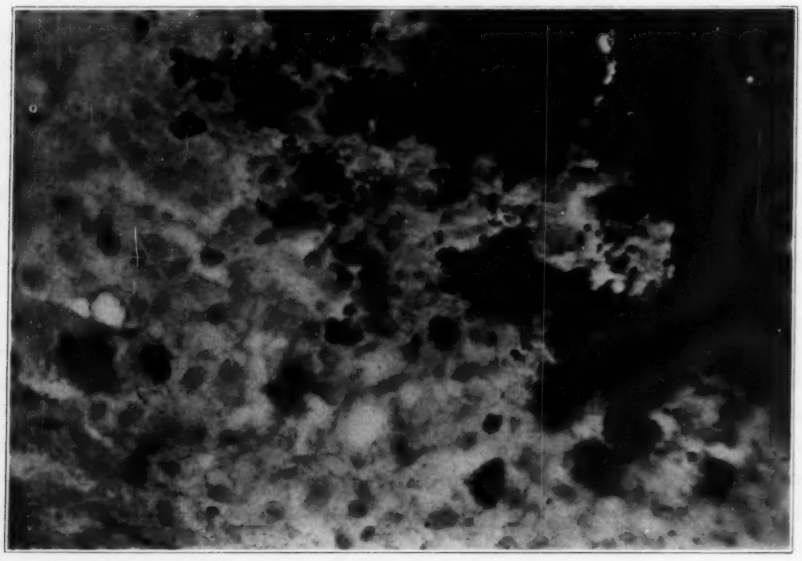


FIG. 12

Photomicrograph (× 467) of section through fracture in the tibia of a rat, after six days of healing, shows crumbling of necrotic bone, small granules of bone salt which are in transit, and free in the tissues; and larger discrete aggregations in macrophages or foreign-body giant cells.

FIG. 13

Photomicrograph (× 173) of section through fracture in the tibia of a rat, after fifteen days of healing. *dnB* indicates a decalcified fragment of necrotic cortical bone in the center of the field, surrounded by cartilage.

Since unopened cartilage cells are frequently included within the matrix of the newly formed bone, the process as a whole may superficially resemble direct transformation of cartilage into bone, but osteogenesis is carried on mainly by the cells carried into the cartilage mass with the advancing blood vessels and primitive marrow. The incorporation of unopened cartilage cells within the matrix produces a picture similar to that of chondro-osteoid in rickets, but the process differs in that here the matrix is heavily calcified. As in the case of the fibrous and fibrocartilaginous tissues, the cartilage masses remain uncalcified except at the periphery, where they are in contact with advancing bone. Occasionally islands of calcified cartilage matrix, in contact with hypertrophic cartilage cells, may be seen in sections, but they can be accounted for by irregularities in the periphery of the cartilage mass.

Bony union, around the defect in the bone, is finally accomplished when the bone advancing from one side of the fracture line gains continuity with that from the other side. From this point on the process is that of reorganization of the callus, and will not be followed further here. Reorganization, however, begins very early in the formation of bony callus, and osteoclasts and the resorption of bone become evident almost as soon as the first trabeculae of bone are formed. Resorption of bone matrix and demineralization of bone occur simultaneously, and such bone as is present during the process of reorganization remains fully calcified.

Necrotic Bone

The ends of the callus-enclosed shaft, which are necrotic from the

first days following the injury, become surrounded by macrophages and foreign-body giant cells containing phagocytosed particles of bone or of bone salt (Fig. 12). A few of these may be found as early as the third or fourth day in the granulation tissue enveloping the ends of the cortex. They become numerous between the fifth and the tenth days, and usually decrease in number thereafter. The most marked degree of phagocytic activity, with respect to particles of bone, is observed in fractures complicated by excessive fragmentation of the shaft. In a number of specimens we have seen particles of decalcified necrotic cortical bone (Fig. 13) and also partially decalcified dead cortical matrix containing crystalline aggregates of bone salt. Usually the bone fragments continue to break down into smaller and smaller particles and the bone salts and the dead bone matrix appear to dissolve at the same or nearly the same time.

Resorption and reconstruction of the section of the shaft enclosed in callus begins with the first formation of the subperiosteal intramembranous bone, and continues throughout the growth and regression of the callus. As a result of these processes the shaft, initially composed of compact bone, becomes at fifteen to twenty-five days of healing almost as porous as spongy bone. The vascular canals of Havers and Volkmann appear enlarged and filled with osteoclasts and osteogenic tissue. In roentgenograms the striking difference between the density of the outer shaft and the callus-enclosed shaft creates the impression of the well-known "atrophy of the cortical ends" of healing fractures. The formation of osteoclasts is almost exclusively limited to the activity of living bone tissues. Such osteoclasts as are found in the vicinity of the necrotic ends of the cortex are formed in enlarged vascular canals, and in crypts, which, prior to the injury, may have been occupied by osteogenic cells. Osteoclasts have not been observed to contain bone salt.

DISCUSSION

The chief contributions of this paper are with reference to the time relationships of calcification in the processes leading to the healing of fractures, and to the nature of tissues in which calcification occurs. Contrary to the usual view it has been shown that the formation of osteoid, or uncalcified osseous tissue, is not a necessary step in the formation of the bony callus. The new bone matrix is calcifiable when it is formed, and under optimum conditions calcification begins as the matrix is deposited. In this respect the process is identical with that in the normal embryogenesis or histogenesis of bone.

The healing of a fracture imposes an added burden upon the calcifying mechanism. Except under optimum conditions, general and local, the added burden may exceed the capacity of this mechanism, a condition which is manifested by the appearance of osteoid because of a lag in calcification. The significance of this finding has been discussed in a previous paper [24] with reference to the normal growth of bone, and need not be considered further here.

No special effort has been made, in this paper, to add to current knowledge concerning the histogenesis of the new bone which leads to union of a fractured bone. However, our preparations demonstrate invasion of the fibrocartilaginous callus by new bone, which calcifies as it advances into the callus mass, and afford striking evidence that the bone originates outside of this mass. The process is analogous to the intracartilaginous growth of bone, in that remnants of the invaded tissue are made use of and converted into bone matrix by the invading osteogenic cells. It is also similar to the intracartilaginous growth of bone in that the process is essentially one of removal and replacement of the fibrocartilaginous callus, rather than of its transformation into bone originating from the connective-tissue cells of the callus itself. According to our observations, new intramembranous bone is formed chiefly from the deep or cambium layer of the periosteum and from the endosteum, including the osteogenic cells within the haversian canals. If the fracture is in or near the spongy bone new bone arises from this source as well, and the bony callus is frequently continuous with the spongiosa. We have made no effort to prove or disprove the origin of bone from the osteocytes of the compact bone, but have not seen evidence that this was possible under the conditions of our experiments.

During the healing of a fracture a number of tissues, all of mesenchymal origin, arise in the callus. Calcification does not occur in a random fashion in these tissues, but is confined to tissues recognizable as bone matrix and as the matrix of hyaline cartilage. As stated above, the bone matrix is calcifiable when formed, and calcification begins in it while it is being laid down. In the case of cartilage matrix, the factors leading to calcification are somewhat more complex. Calcifiability is conferred upon the matrix of hyaline cartilage when the adjacent cartilage cells reach a stage recognizable as fully grown or hypertrophic. In this respect the hyaline cartilage of the callus resembles that in the epiphyseal cartilage plate [24] and in the embryonic cartilage models of bones [4], but calcification occurs in this matrix only when contact between the cartilage and the invading bone is established. Owing to the irregular distribution of the hypertrophic cartilage cells, resulting from the formation of nodular masses of cartilage, calcifiable cartilage matrix may be formed within the cartilage mass at some distance from the invading bone, while part of the cartilage matrix in contact with the invading bone is not calcifiable. Under these conditions some of the calcifiable matrix will not calcify, while the unprepared matrix, being invaded by bone, will calcify only when converted into bone matrix. In this respect it behaves in the same way as does fibrous tissue or fibrocartilage.

The extent to which the orderly sequence of events in the healing of a fracture depends upon calcification does not immediately become apparent from a study of fractures in normal animals. The interdependence of calcification and of the formation of normal osseous tissue is considered in detail in the paper which follows [27].

In addition to formation of new bone, the healing of a fracture involves resorption and reorganization of pre-existing cortical bone and of bone tissues formed provisionally in the callus. In these respects also there is a resemblance to the normal formation and growth of bone. In the case of the fracture, however, there is the additional necessity of the removal of necrotic bone. According to our observations, the latter process occurs by a process of liquefaction of both the organic and inorganic elements of bone, in which the inorganic substance may be removed in advance of the organic matrix, but in which osteoclasts play no part.

Macklin [22] and Chiariello [7], using trypan blue, and Micotti [25], administering lithium-carmine, studied the activity of macrophages in the callus at various stages of healing of fractures. Macklin interpreted his observations as indicating that the phagocytes ingest some, at least, of the products resulting from liquefaction of the callus, but states "that the liquefied bone salts are phagocytosed by macrophages seems entirely doubtful".

We have demonstrated the engulfment of particles of bone, including their bone salt, within macrophages and foreign-body giant cells, and have found that the most marked degree of activity is observed in fractures complicated by excessive fragmentation of the shaft. Gersh [15, 16] has shown that colloidal calcium phosphate may be removed from the blood stream by the macrophages of the liver and spleen, and Bloom and McLean [5] have demonstrated bone salt in the macrophages of the bone marrow under various conditions of rapid resorption of bone. A similar phenomenon occurs also during the liquefaction of necrotic fractured bone. Large fragments of dead bone excite a foreign-body reaction in the surrounding tissues, while smaller particles of dead bone or bone salt free from matrix may be phagocytosed by macrophages. These phenomena will be discussed further in a later paper, reporting our investigations upon the fate of dead bone implanted within the callus.

In contrast to the resorption of necrotic bone in the absence of osteoclasts, but in the presence of foreign-body giant cells, the resorption of living bone, where reorganization is to take place, is accompanied by the presence of large numbers of osteoclasts. Bone salt has not been seen to be phagocytosed by these cells. This finding is in agreement with those in other conditions associated with the rapid resorption of bone [5].

SUMMARY AND CONCLUSIONS

1. The healing process in the fractures observed is essentially one of formation of a fibrocartilaginous callus in and around the defect in the shaft, and the subsequent invasion, removal, and replacement of the fibrocartilaginous mass by new bone arising from the cambium layer of the periosteum and from the endosteum.

2. The progress of calcification in this process has been observed by impregnation of undecalcified sections with silver nitrate. By this method, which is extremely sensitive for bone salt, no deposition of salt is observed in the procallus, or prior to the formation of osseous tissue.

3. Bone matrix is formed subperiosteally and subendosteally, first at some distance from the fracture line, at about the second or third day following a fracture. It is calcified as it is laid down under optimum conditions with no appreciable interval between its formation and the deposition of bone salt within it. As the new bone invades the fibro-cartilaginous callus, it removes the fibrous tissue, fibrocartilage, and hyaline cartilage, replacing them by bone matrix. In this process remnants of the invaded tissue may be utilized and converted into bone matrix by the invading osteogenic cells. In all instances the new matrix is calcifiable as soon as it is recognizable as osseous tissue.

4. A lag in calcification of newly formed osseous tissue may occur. This is attributed to failure in the supply or transport of bone minerals, rather than to lack of calcifiability in the bone matrix.

5. The matrix of hyaline cartilage becomes calcifiable when the adjacent cartilage cells become vesicular or hypertrophic. The calcification of cartilage matrix is further conditioned by its relationship to the bone tissue invading the fibrocartilaginous callus. Only matrix in contact with the invading bone calcifies, and, if the matrix has not been made calcifiable by hypertrophy of the adjacent cells, it calcifies only when converted into bone matrix by the advancing osteogenic process.

6. Only tissues recognizable as bone matrix or cartilage matrix calcify in the callus. There is no random calcification in the fibro-cartilaginous callus, the great mass of which remains completely free from bone salt except where it is invaded and converted into bone from its periphery.

7. Particles of bone, including their bone salt, have been demonstrated in foreign-body giant cells and in macrophages during the resorption of necrotic bone. Fragments of dead cortical bone have been observed to undergo decalcification in advance of the disintegration of the bone matrix. This differs from the process of resorption of living bone, in which the bone mineral and organic matrix are removed simultaneously. No phagocytic activity of osteoclasts, either for particles of bone or for bone salt, has been demonstrated.

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MICROSCOPIC CHANGES AFTER INTERNAL FIXATION OF TRANSCERVICAL FRACTURE OF THE FEMUR

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AND J. V. LUCK, M.D., LOS ANGELES, CALIFORNIA

Pathological changes and resistance to former methods of treatment, peculiar to intracapsular fracture of the hip, account for the widespread acceptance of the principles of internal fixation now in vogue. Despite the interest evinced in these injuries there are, in the literature, very few complete pathological studies of the fracture site so treated. It is our purpose to describe the microscopic findings in such a postmortem specimen. It was obtained from an elderly woman fifty-two days after injury, and forty-three days after transfixation by a Smith-Petersen nail. Death was probably due to a cardiovascular complication.

Palmer, in 1934, reported the result of a histological examination of the hip region from a woman, aged seventy, who had died of some disease unrelated to the injury, barely three months after fixation by a Smith-Petersen nail. In spite of the marked, and still active, absorption of the neck, and almost complete necrosis of the head, healing was progressing satisfactorily. Bony union had commenced in the distal fragment through metaplastic bone formation in tissue intimately bound up with its periosteal-synovial coverings. The regenerative processes of the spongiosa of the necrotic head were taking place through the marrow of the head, which had become revascularized by vessels from capsule periosteum, and not through callus growing in from the distal end of the fracture. The rustless steel nail, though partially extruded (12 millimeters) due to the absorptive processes in the neck, did not have any untoward effect upon the spongiosa or the reparative processes.

Another specimen, studied by Jones and Lieberman in 1938, was obtained from a female, aged fifty-two, eight days after fracture and only seven hours after fixation with a Jones screw. Death was due to probable multiple pulmonary emboli. The fracture involved the base of the neck and the lesser trochanter. The gross specimen revealed, besides the linear defect due to the insertion of the screw, a large triangular defect in the neck which was filled with brownish granular detritus, and marked by a complete absence of endosteum. Histologically there was almost complete necrosis of the neck along with focal areas of necrosis in the head. They felt that the widespread necrosis, which was observed in their case, may be present in varying degrees in all cases. It is this factor which probably puts this lesion in a class by itself, since the screw was certainly not responsible for these changes. They concluded "that sometimes this condition is a pathological fracture, and that the same fault which causes the fracture is the one responsible for delayed healing or even complete non-union."

FIG. 1

Photograph of postmortem specimen taken November 23, 1938.

CASE REPORT

Mrs. Lula R. (E1944) a white female, whose stated age was sixty-five years, was admitted to the St. Joseph Hospital on October 2, 1938, several hours after her injury. According to her medical attendant, Dr. H. W. Carle, she had suffered for years from an extensive vascular disease with concomitant hypertension. She was poorly nourished and appeared to be about seventy-five years of age. The general examination revealed a cataract of the left eye, edentulous jaws, funnel breast, scattered pulmonary râles, a systolic apical bruit with regular rhythm, and a blood pressure of 222/122. The left lower extremity presented the usual picture of a typical varus subcapital fracture. The temperature was 100 degrees, the pulse ninety-six and respiration twenty-two. Laboratory investigations revealed nothing relevant. Except for a tendency toward development of a sacral decubitus, she responded favorably to preliminary Russell traction. Her temperature, pulse, and respiration became normal one week after admission.

On October 11, 1938, under spinal anaesthesia, and roentgenographic control a three and one-half inch White rustless-steel Smith-Petersen nail was inserted following Leadbetter's method of manipulation and reduction. A postoperative roentgenogram showed excellent reduction (valgus), impaction of the fragments, and optimum low position of the nail. Postoperatively she ran an irregular low-grade fever which gradually returned to normal in a week. The traction and dermal sutures were then removed. On the following day she was permitted to sit up over the edge of the bed. She was discharged on November 4, 1938. The patient continued to make good progress at home. She was permitted to sit up in a chair daily, to stand with aid several times a day, and was encouraged to exercise the limbs in bed. On November 22, 1938, she suddenly complained of severe abdominal discomfort, headache, and vomiting. Coma and death occurred on the following day. The hip specimen was obtained at the mortuary several hours later.

HISTOLOGICAL STUDY *

Gross Pathology

The subcapital fracture of the femoral neck was firmly transfixed by a metal pin (Figs. 2-A and 2-B), the head of which protruded from the lateral femoral cortex just below the vastus lateralis ridge. The fracture fragments were well apposed. There was an apparent one-eighth inch distal displacement of the distal fragment due to valgus and impaction of the femoral head. Inferior to the fracture site a thin layer of fibrous tissue continuous with the periosteum bridged across the fragments. There was no evidence of periosteal callus. About one square centimeter of cortical plate was missing from the superior aspect of the femoral neck. This appeared to have been lost during the recovery of the specimen. The specimen was mounted in plaster-of-Paris, the pin was extracted, and then frontal sections were cut with a band saw (Fig. 3).

On frontal section it was evident that an early stage of bony union had been attained. Fibrous marrow and a multitude of minute trabeculae characterized the fracture area. Except for some small scattered areas and a narrow subchondral zone, the marrow of the

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capital epiphysis was fatty; all other marrow in the specimen appeared to be grossly hematogenous. Only a slight degree of osteoporosis was present. The articular cartilage was nowhere denuded or fibrillated, but was somewhat dull and in most areas opaque. The articular cortex was grossly intact. Surfaces of the bone, adjacent to flanges of the Smith-Petersen nail, were smooth and presented no porosis or sclerosis detectable by gross examination.

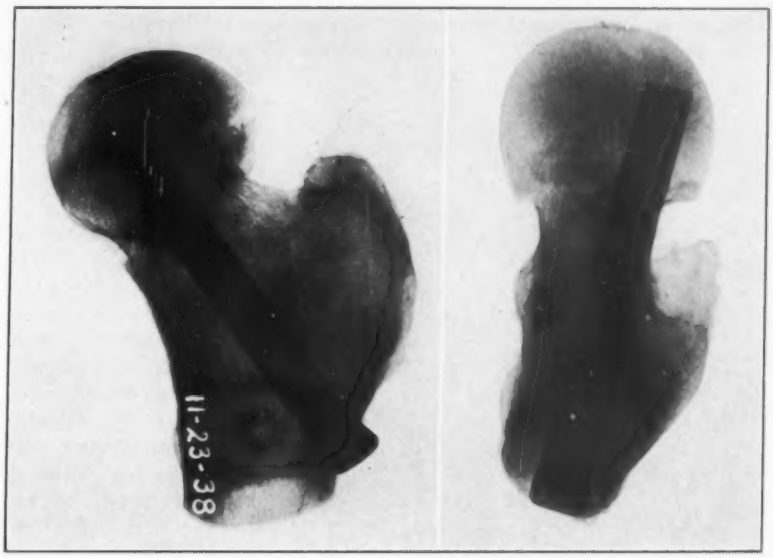

FIG. 2-A FIG. 2-B

Roentgenograms of anteroposterior and lateral views of the postmortem specimen.

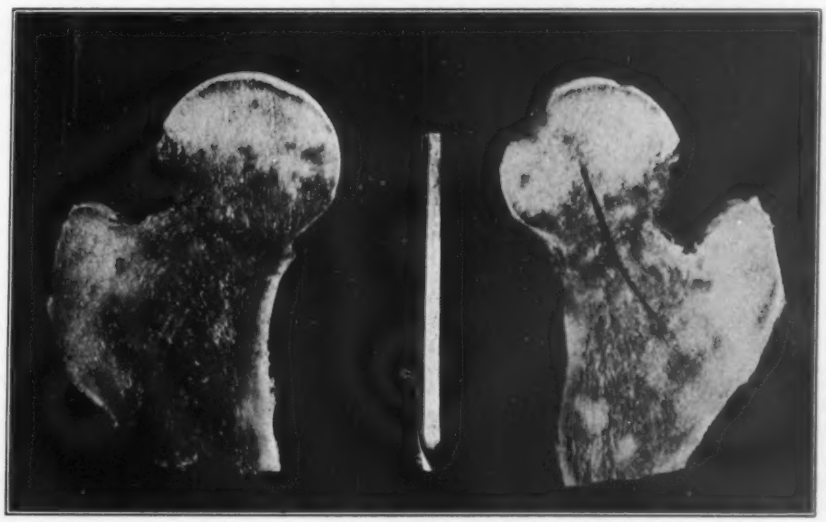

FIG. 3

Photograph of postmortem specimen divided in frontal section. The Smith-Petersen nail is shown between the halves of the specimen.

Microscopic Examination

By the use of a celloidin technique one-piece histological sections were made of the entire specimen. These sections were mounted on lantern-slide-size plates.

Fracture Site

The most outstanding feature of the fracture site was the presence of a multitude of fine-caliber, short, narrow, smooth trabeculae, more than half of which were still in the osteoid stage. Osteoclasts were conspicuous for their paucity. A moderate number of small osteoblasts were attached to the surfaces of some of the trabeculae. Most trabeculae appeared to have formed on the basis of fibrous tissue. These small young trabeculae were aligned in all directions, with no respect for static lines of stress. A few large mature bony trabeculae were also present in the fracture zone. Many of these trabeculae were dead, presumably as a result of separation from their blood supply at the time of the fracture. New bone was applied to the surfaces of numerous old trabeculae at and adjacent to the fracture site. A considerable degree of hyperaemia existed in the vessels of the fibrous marrow in this region. Marrow fibrosis was sharply limited to a zone approximately one-quarter inch wide at the fracture level (Fig. 4). Beyond this zone the marrow appeared quite normal. Not a solitary field of cartilage in any form could be found at the fracture site. The healing process appeared to consist simply of the formation of osteoid and bony trabeculae on the basis of reactive fibrous tissue which developed between the fragments and in adjacent marrow spaces.

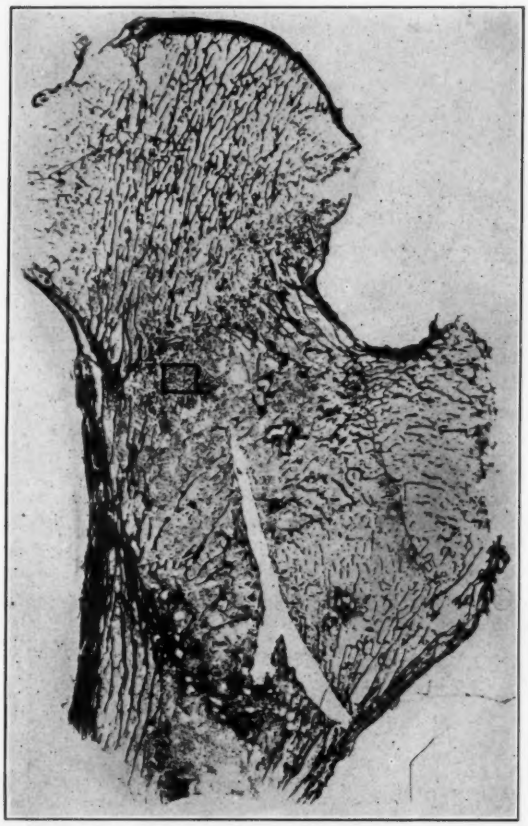

FIG. 4

Photograph of a histological section of the entire specimen. (See photomicrograh, Fig. 5.)

Femoral Head

Vascularity of the femoral head was not interrupted by the fracture, since very few necrotic trabeculae could be found beyond the immediate vicinity of the fracture. Several interruptions existed in the articular cortex as a result of reactivation of endochondral ossification. The zone of provisory calcification had proliferated to a considerably increased width and was being invaded at a few points with new bone which was applied to the margins of the small inroads. A few subjacent intratrabecular islands of calcified cartilage further testified to the beginning reactivation of endochondral ossification such as is observed in degenerative arthritis. The articular cartilage was of normal thickness and had a smooth gliding layer. Deeper layers showed a tendency toward basophilic staining, together with numerous Weichselbaum's lacunae containing several chondrocytes.

Neck and Trochanter

The neck and trochanteric regions revealed a good blood supply with viable trabeculae and marrow. The periosteum was interrupted and moderately thickened at the

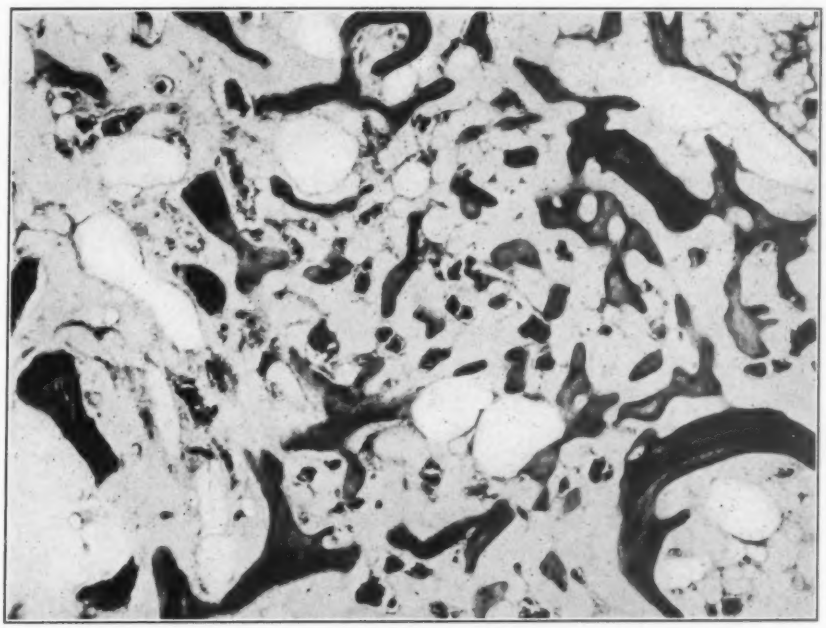

FIG. 5

Photomicrograph of the section of the fracture site shown in the square in Fig. 4.

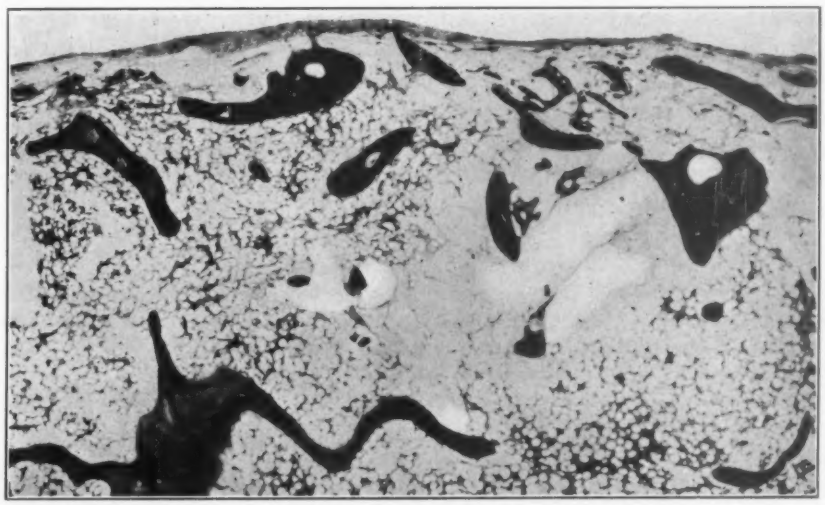

FIG. 6

Photomicrograph of a section of bone adjacent to a flange of the Smith-Petersen nail, showing the thin layer of fibrous tissue which formed as a minimal reaction to the nail.

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fracture site. On the inferior surface of the neck a thin bridge of fibrous tissue spanned the break in the periosteum. No subperiosteal new-bone formation was noted. Most bony trabeculae of the specimen were bordered by a thin layer of newly apposed bone, evidently a result of the stimulus of early activity which came from good fixation of the fragments.

Reaction Around the Stainless Steel Pin (Fig. 6)

The surfaces bordering the flanges of the nail were smooth and were covered by a layer of rather cellular fibrous tissue of microscopic thickness. Beneath this layer in some fields there was a tendency for subjacent bony trabeculae to combine to form a lamellar plate. In most fields there was no response whatever beneath the fibrous layer. A few chopped-off or fragmented trabeculae were seen and some of these were necrotic. There was surprisingly little evidence of trauma inflicted by the insertion of the pin. No inflammatory cells were found anywhere in the specimen.

CONCLUSIONS

The several features which are outstanding on the basis of our microscopic examination are:

1. The simplicity of and the rapid progress made by the healing process.
2. The absence of cartilage from the healing process at the fracture site.
3. The absence of subperiosteal reaction or peripheral callus.
4. The minimal evidence of trauma inflicted by the insertion of the pin.
5. The minimal reaction of the tissues to the presence of the pin.
6. The absence of significant osteoporosis, and the apposition of new bone on trabecular surfaces at such an early period after fracture.

It is quite clear from a study of our specimen that any method of internal fixation which meets mechanical requirements—such as good reduction, elimination of shearing stress at the fracture site, and adequate fixation of fragments *which are and remain in an excellent state of nutrition*—will result in bony union much sooner than has been generally appreciated in the past. These fundamentals should be borne in mind, since the prominence of technical detail has tended to subordinate some basic pathological and clinical aspects of the problem as a whole.

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GROWTH OF THE EPIPHYSES

BY JOHN A. SIEGLING, M.D., F.A.C.S., URBANA, ILLINOIS

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It is now generally accepted that growth of the diaphysis takes place at the cartilage columns in the epiphyseal plate, and that certain growth cartilages contribute more than others to longitudinal growth.[2, 13, 19] Proof of these facts was in part due to the proper interpretation of transverse lines observed in long bones following the clinical and experimental administration of phosphorus.[22, 29] The pathology of these transverse opacities was speculative until 1927, when Eliot[6] demonstrated that they were the result of a bony lattice work, produced by the enlargement and cross branching of the trabeculae, which at times illustrated even transverse bridging. The increased mass of bone at these areas presents a greater obstruction to roentgen rays than the normally trabeculated bone, resulting in the appearance of a line in the roentgenograms. Lines have been observed also in cases of congenital syphilis, in severe illness (particularly scarlet fever), in lead poisoning, and after ingestion of certain drugs. Microscopic section of teeth has demonstrated concomitant formation of lines as new enamel is added.[25]

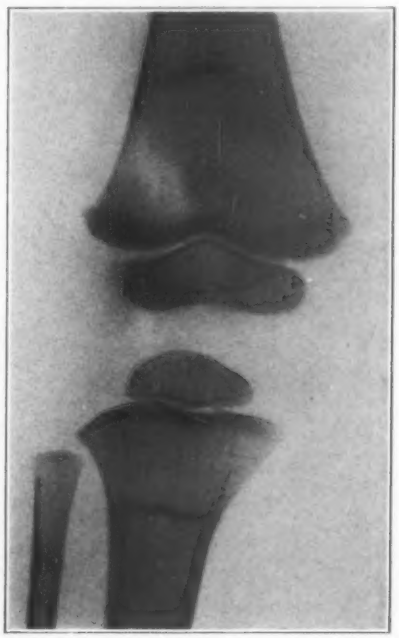

FIG. 1

Roentgenogram shows radiopaque lines in the diaphyses of the femur, tibia, and fibula of a child who received phosphorized cod-liver oil some time before. Growth at the distal end of the femur is greater than at the proximal ends of the tibia and fibula. The lines in the epiphyses proper are notable.

In cases where phosphorus has been administrated intermittently, multiple lines have been observed. By measurement of the distances of these lines from their respective epiphyses, the amount of growth occurring in one portion of a bone can be compared with the growth of other parts of the same or other bones. The careful study and measurement of the lines as they appear in the *diaphyses* of *long* bones has added to our knowledge of bone growth by clinical corroboration of experimental work. They not only show the relative amount of growth taking place at the ends of long bones, but also prove

beyond doubt that shaft growth is the result of activity on the diaphyseal side of the epiphyseal cartilage.

Scant attention has been given the subject of growth of the epiphyses.

FIG. 2

Photomicrograph (×65) of epiphyseal cartilage.

a: Columns of cartilage streaming into the diaphysis. Active endochondra ossification is taking place. Shaft growth is localized here.

b: Epiphyseal side of the epiphyseal cartilage shows no evidence of active endochondral ossification.

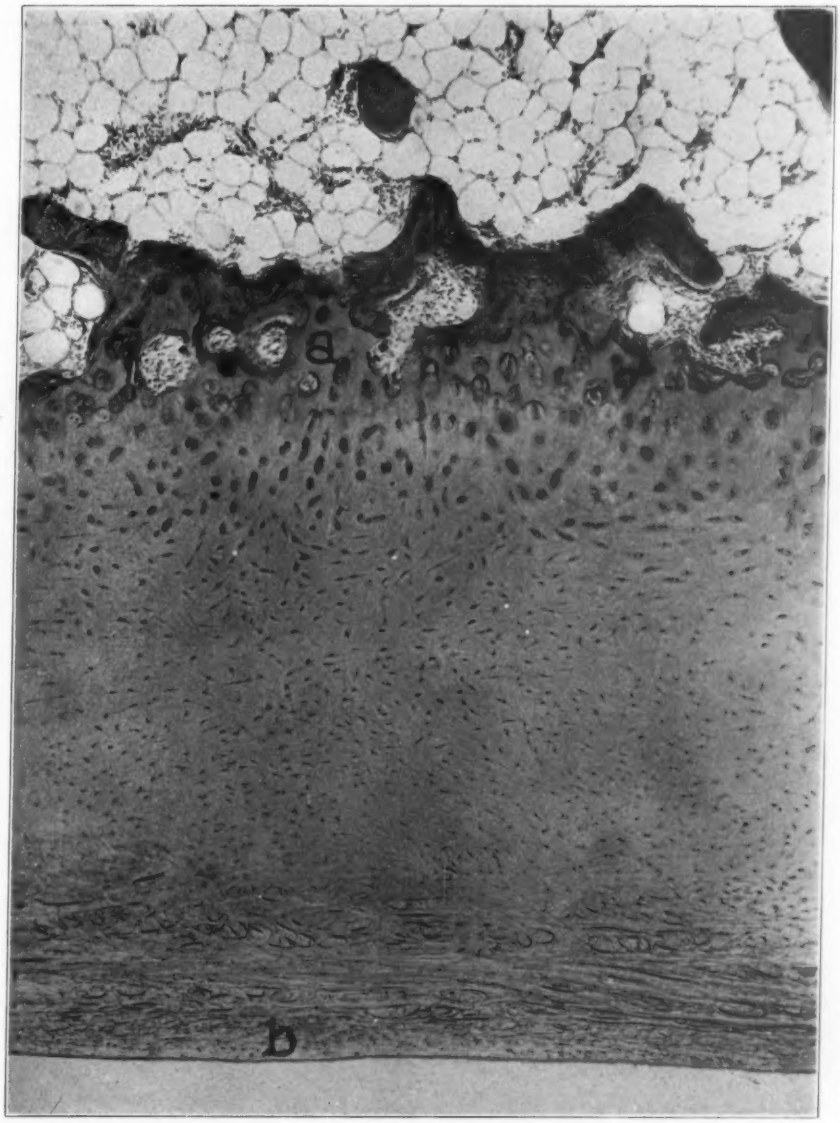

FIG. 3

Photomicrograph (×65) of cross section of articular cartilage.
a: Juxta-epiphyseal side of articular cartilage. Note rather active endochondral ossification.
b: Articular surface.

Available information is largely contradictory and poorly substantiated, and there is no consensus concerning growth of the epiphysis itself.[1, 3, 8, 16]

Our attention has been attracted for some time to the appearance of lines in the epiphyses of children as a result of disease or phosphorized cod-liver-oil medication (Fig. 1). Since interpretation of the radiopaque lines in the diaphyses has thrown light on shaft growth, it was thought

FIG. 4

Roentgenogram of pelvis of the child in Fig. 1. Note how the phosphorous line (*a*) conforms to the curve of the epiphysis of the crest of the ilium. The angled radiopaque line (*b*) illustrates that growth at the proximal end of the femur is the result of two forces, the capital and trochanteric epiphyseal growth centers, which at this time actually act as one.

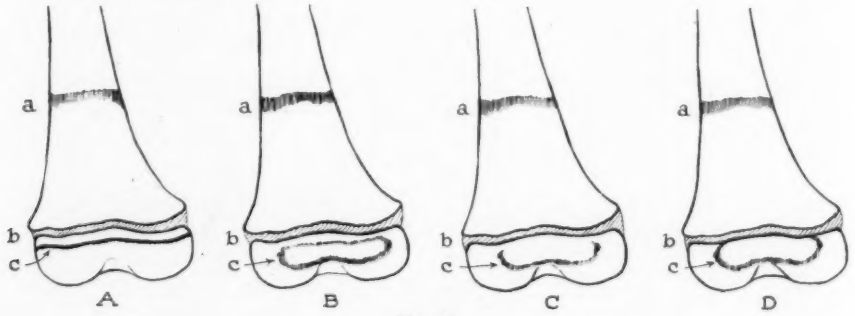

FIG. 5

Diagrams of the ends of four bones showing:
a: Growth line in shaft; *b:* Epiphyseal cartilage;
c: Hypothetical growth lines in epiphyses as discussed in text.

that study of similar lines occurring in epiphyses might clarify the question regarding their method of growth. We now believe that an interpretation of these lines presents very definite proof of how epiphyseal growth occurs.

As a background for the study of epiphyseal growth it is perhaps wise to consider the cellular structure and physiology of epiphyseal and articular cartilage, respectively, in cross section. The columns of cartilage (*a* in Fig. 2) streaming off into the diaphysis are readily seen. The

FIG. 6

Roentgenogram of pelvis of a girl with dyschondroplasia shows:
a: Wide phosphorous line; *b:* New bone added since cessation of medication;
c: Line corresponding to *a*; *d:* New bone added after discontinuance of medication;
e: Line corresponding to *a* and *c*.

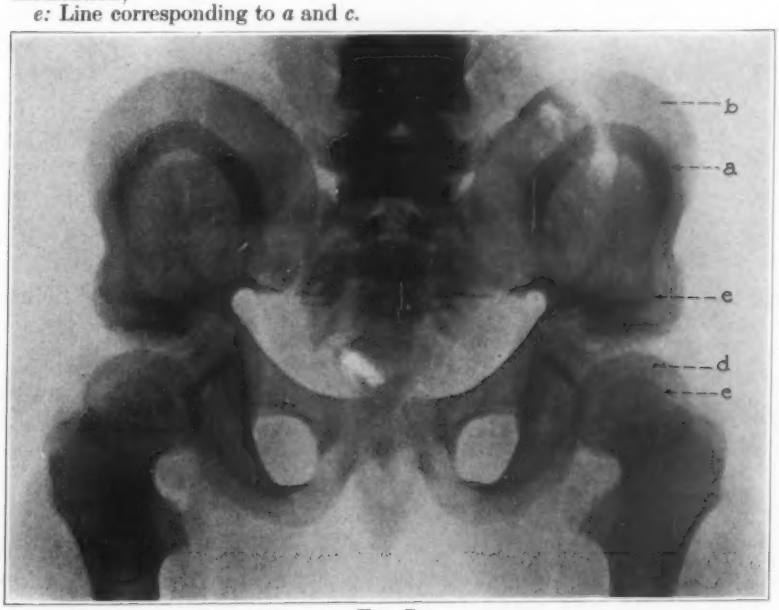

FIG. 7

Roentgenogram of same pelvis as Fig. 6, taken three years and four months later. Note increase in width of *b* and *d*. There is no translucent area in the region of the epiphyseal plate. The distance from *e* to the articular surface of the acetabulum is much increased.

FIG. 8

Roentgenogram shows phosphorous lines in vertebrae, and illustrates addition of new bone superiorly, inferiorly, and anteriorly.

experimental work of Haas [11, 12] has positively localized this area as the source of shaft growth. Careful study of the juxta-epiphyseal side of the epiphyseal cartilage (*b* in Fig. 2), however, fails to show any signs of endochondral ossification. On the other hand, scrutiny of the juxta-epiphyseal side of the *articular* cartilage (*a* in Fig. 3) reveals definite signs of endochondral ossification, though to a lesser degree, of course, than on the shaft side of the epiphyseal cartilage. This is microscopic evidence that growth activity in the epiphysis is confined to the articular cartilage.

There has been considerable controversy about whether the youngest articular cartilage cells are those bathed by the synovial fluid or those nearest the bone. Ogston [18] believed "that articular cartilage is constantly renewing itself from a focus of central growth, and grows in two directions". He believed that an effete layer was formed toward the joint, which was worn away by joint movements. Fisher [7] showed clearly that these "effete" cells, far from being degenerate, are the source from which the deep cells are derived, and are analogous to the perichondral cells of costal cartilage.

Epiphyseal and articular cartilages are normally avascular [14] and present the typical mode of growth of a vegetative tissue. The experiments of von Tappeiner [26] demonstrated that in transplanting the radial head of one rabbit to another the cartilage usually lived while the bone became necrotic. This has been proved experimentally by others also. Clinically

the behavior of loose bodies within joints is analogous. In cases of osteochondritis dissecans it has been shown that the osseous components of the fragments necrose early, whereas the cartilage cells remain alive for varying periods of time. Bathed in synovial fluid their environmental and nutritional status remains essentially the same whether they are attached to the subchondral bone or free in the joint. They have even been observed to grow progressively larger by proliferation of fibrocartilage cells,[23] and they usually assume a more spherical shape. At times even the bony elements increase, so that the osseous nucleus becomes larger than the original bony particle. Thus, articular cartilage not only may live, but proliferate and undergo ossification without direct blood supply.

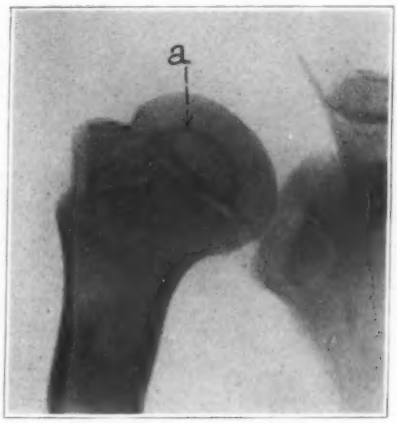

FIG. 9

Roentgenogram of proximal humeral epiphysis in the same child. Note that the ends of the semicircular line (*a*) extend down to the epiphyseal line.

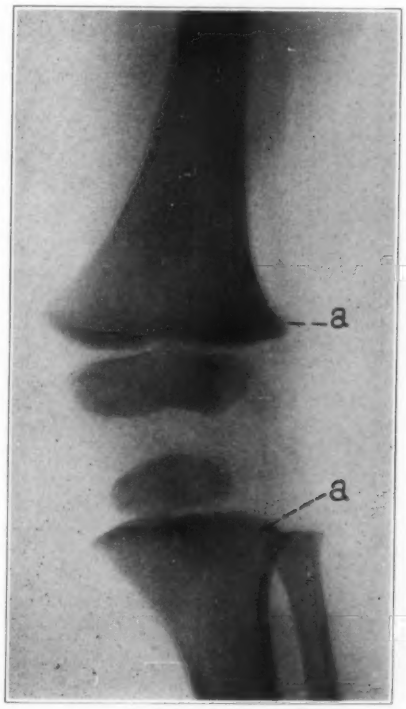

FIG. 10

FIG. 11

Fig. 10: Roentgenogram of knee shows formation of phosphorous lines (*a*).
Fig. 11: Roentgenogram of the same knee as shown in Fig. 10 illustrates multiple lines as a result of intermittent phosphorized cod-liver-oil medication.

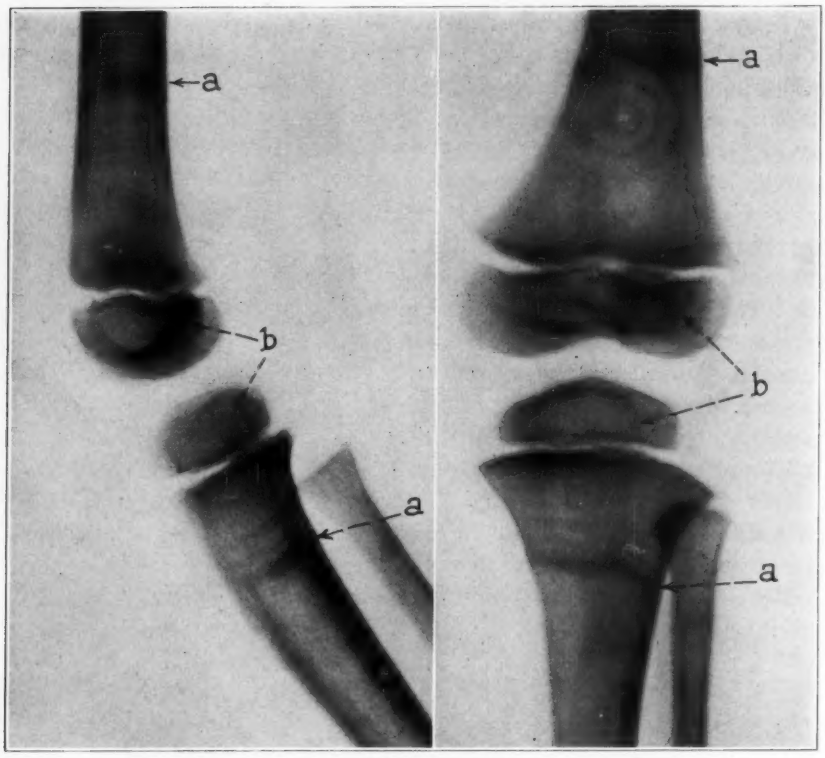

FIG. 12

Roentgenograms of the same knee as shown in Fig. 11 taken four years later. The lines (*a*) are much more distant from the epiphyseal lines and are fading. The limbs of the figures (*b*) within the epiphyses extend down to the epiphyseal lines.

With these points in mind, study of roentgenograms showing phosphorous lines is illuminating.

In the roentgenograms of children, radiopaque lines due to lead, bismuth, phosphorized cod-liver oil, etc., have been observed to assume very definite patterns.[4, 5, 20, 28] These patterns depend upon the method of growth of that particular epiphyseal cartilage. For example, note the opaque lines formed by the growth cartilages of the ilium and the proximal end of the femur in Figure 4. Study of these lines gives concrete evidence of the process of growth in each place.

Assuming that similar radiopaque lines would form in the epiphyses proper, we might expect to find one of four patterns, depending upon the localization of growth. Should the increment of growth contributory to the enlargement of the *epiphysis* take place solely from the epiphyseal plate, we might reasonably expect a line such as *c* in Figure 5-A. On the other hand, if growth of the epiphysis were equally divided between the epiphyseal and articular cartilages, we might conceivably find a pattern such as *c* in Figure 5-B. Should both areas contribute to growth and the transverse line fail to form, the appearance would be as shown in *c* of

Figure 5-C, in which the limbs of the figure fail to extend to the epiphyseal cartilage. If growth of the epiphysis were the result *solely* of the *articular* cartilage, we should find a pattern similar to *c* of Figure 5-D. Study of the roentgenograms of many cases showed only epiphyseal growth lines as illustrated by Figure 5-D.

In the pelvis of a girl with dyschondroplasia (Fig. 6) the broad lines (*a*) in the ilia represent a period of phosphorus therapy. The more transparent bone (*b*) has been added since discontinuance of the medication. The capital femoral epiphyses show a semilunar line (*c*) which corresponds to the lines observed in the ilia. The peripheral, less opaque area (*d*) is comparable to *b*. Three years and four months later (Fig. 7) the wide bands in the ilia appear more centrally placed, due to addition of new bone by the growth cartilage of the iliac crests. The pattern within each capital femoral epiphysis is significant. The narrow, more radiotranslucent semicircle of bone on the periphery has become much wider because of endochondral growth and ossification from the articular cartilage. There is no evidence of new bone on the epiphyseal side of the epiphyseal plate.

The proximal humeral epiphysis (Fig. 9) of the same child shows a similar configuration. The limbs of the phosphorous line (*a*) extend down to the epiphyseal cartilage and new bone has been added peripherally.

Interpretation of lines observed within vertebrae (Fig. 8) leads to the conclusion that very little bone accrues posteriorly. Increase of size takes place principally in the other directions.

FIG. 13

March 20, 1934, Roentgenogram of same case as Figs. 10, 11, 12 shows phosphorous line forming at the crest of the ilium and roof of the acetabulum.

FIG. 14

Roentgenogram of same case shown in Fig. 13, taken three years later. The lines within the capital epiphyses are faint, but can be seen to extend to the epiphyseal line. New bone has been added at the superior portion of the acetabulum and crests of the ilia, causing the phosphorous lines to appear more centrally placed.

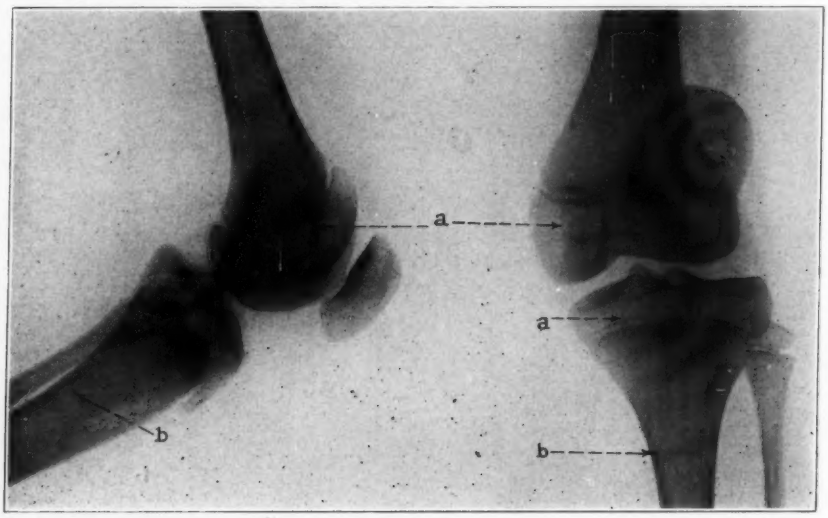

FIG. 15

Roentgenograms of knees show the limbs of the epiphyseal figures (*a*) extending to the epiphyseal lines. New bone seems to have been added to the epiphysis everywhere except at the epiphyseal cartilage. Fading transverse lines (*b*) are seen in the tibiae. Corresponding lines have presumably already faded from the femora.

Figure 10 shows the formation of phosphorous lines (*a*) during administration of phosphorized cod-liver oil. The medication has been discontinued and resumed at intervals, causing the formation of multiple lines (Fig. 11) which progressively become more distant from the epiphyseal line as new bone is added. Four years later (Fig. 12) the transverse lines (*a*) in the diaphysis are still farther away from the epiphyseal line and are fading. The limbs of the lines (*b*) in the epiphyses extend to the epiphyseal lines and new bone has been added by growth and ossification from the articular cartilage. Figures 13 and 14 illustrate well the growth of the epiphyses about the pelvis in the same case over a period of three years.

The lines (*a*) of Figure 15 are probably the result of disease. The limbs of the figures within the epiphyses extend down to the epiphyseal plate. New epiphyseal bone has been added by articular cartilage only. The remains of transverse lines (*b*) are seen in the tibiae, but have completely faded from the femoral shafts. This child did not have phosphorized cod-liver oil. The etiological factor was probably a mild case of scarlet fever five years earlier.

Intermittent administration of phosphorized cod-liver oil has caused the formation of multiple lines in Figure 16. Four years later (Fig. 17) the multiple lines in the shaft have almost disappeared. The limbs of the figures within the epiphyses extend to the epiphyseal cartilage plate.

Roentgenograms of knees of growing children which had been surgically fused were next studied. In these cases the articular cartilage of tibia and femur had been removed and fusion of the bony centers of the epiphyses had occurred.

In view of the findings observed in the previously described roentgenograms, it was postulated that with removal of the *articular cartilage* and fusion of osseous elements of the adjacent epiphyses of femur and tibia, the epiphyseal

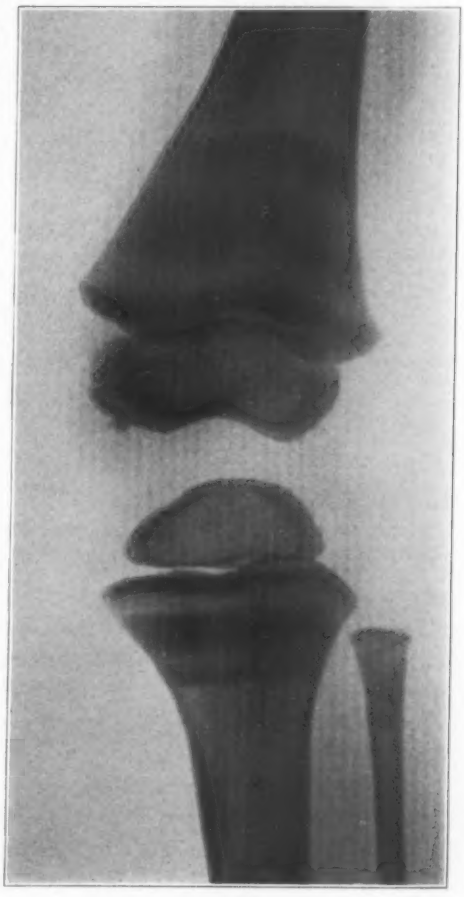

FIG. 16

Roentgenogram illustrates transverse diaphyseal lines due to interrupted medication. Note the lines within the epiphyses.

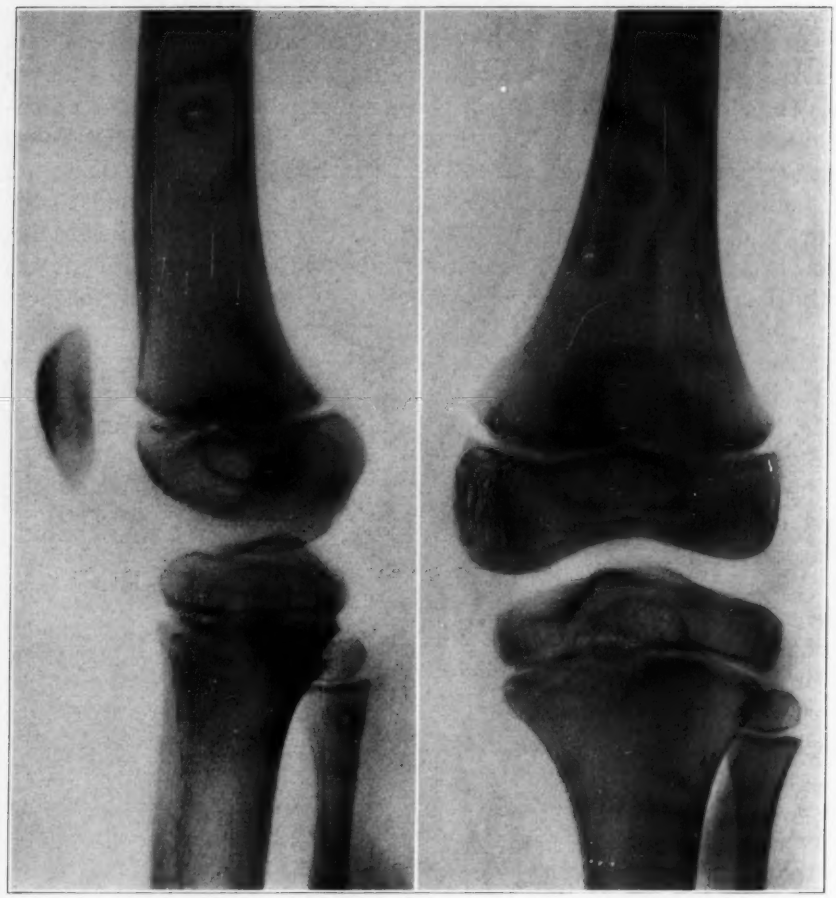

FIG. 17

Roentgenogram of same case as shown in Fig. 16. The diaphyseal lines have faded, but the lines within the epiphyses form a characteristic figure in which the limbs extend to the epiphyseal line, which is evidence against growth having taken place on the epiphyseal side of the growth cartilage.

cartilage plates should not grow farther apart. In other words, the vertical diameter of the combined epiphyseal nucleus should not increase. Figure 18 is representative of this group. The two epiphyses have formed one bony block (*a*) between the epiphyseal cartilages (*b*) of the tibia and femur. New phosphorous lines (*d*) are being produced.

Three years and four months later (Fig. 19), there has been a marked increment in shaft growth. The lines (*d*) of Figure 18 are now represented by (*d*) of Figure 19. The vertical diameter of the combined epiphyseal block has not increased. This is confirming evidence that articular cartilage is necessary for longitudinal growth of the epiphyses and that the epiphyseal cartilage has not contributed in any appreciable degree to the size of the combined epiphyses.

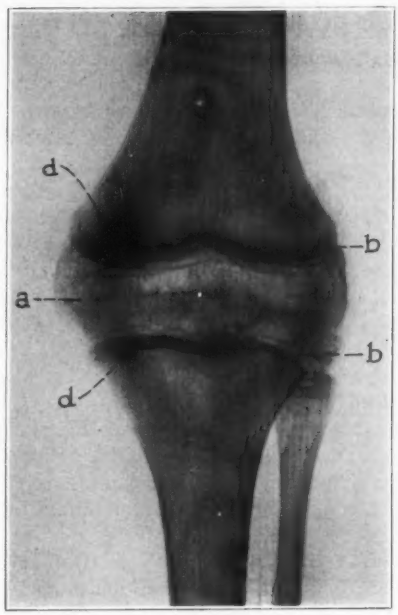

FIG. 18

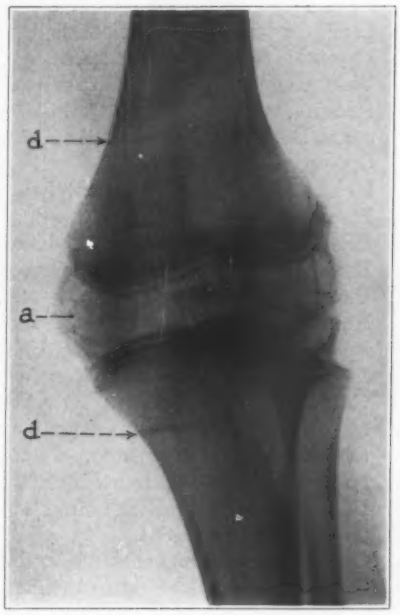

FIG. 19

Fig. 18: Roentgenogram of a surgically fused knee.
a: Combined epiphyseal block; *b:* Epiphyseal cartilage; *d:* Early phosphorous line.
Fig. 19: Roentgenogram of same knee taken three years and four months later. Diaphyseal growth has been active. Early phosphorous lines (*d* of Fig. 18) are now represented by lines *d*. The vertical diameter of the combined fused epiphyses (*a*) is not increased.

CONCLUSIONS

1. Growth of the epiphysis takes place by proliferation of the articular cartilage followed by endochondral ossification.

2. The epiphyseal cartilage is a negligible factor in longitudinal growth of the epiphysis, if it contributes at all.

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PSEUDO-PLATYBASIA: RUPTURE OF THE TRANSVERSE LIGAMENT OF THE AXIS WITH DISPLACEMENT OF THE ODONTOID PROCESS AND COMPRESSION OF THE CERVICAL CORD

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INTRODUCTION

Chamberlain [1], List [3], and Schüller [5] have recently called attention to a condition known as platybasia, or basilar impression, which has long been recorded in the German literature but little discussed by American clinicians.

Platybasia is a deformity of the occipital bone and the upper end of the cervical spine, variously attributed to rickets, osteitis deformans, osteomalacia, long-standing, increased intracranial pressure, or developmental anomaly. Schüller states that traumatic "basilar impression" has no practical importance inasmuch as such cases are nearly always fatal. Trauma to the head and neck may be of considerable importance, however, in influencing the progression of the disease, whatever the primary etiological factors are. Thus it is of some interest that platybasia is more frequent in countries where it is the custom to carry all burdens on the head [5].

Platybasia is characterized by an upward displacement of the clivus and a narrowing of the foramen occipitale magnum so that the medulla and the cervical cord are subjected to varying degrees of compression. The clinical picture is variable but often simulates disseminated sclerosis, syringomyelia, cerebellar tumor, or progressive spastic paralysis, depending upon the sites of pressure. X-ray examination of the occipital region reveals characteristic changes. Surgical intervention may lead to dramatic recovery.

We have recently had the opportunity to examine at postmortem a patient in whom the condition of platybasia was closely simulated as the result of trauma sustained thirty years previously. The case is of particular interest in that the patient was able to survive with a minimal amount of permanent damage to the nervous system in spite of an extremely acute onset of symptoms.

CASE HISTORY

The patient, a forty-five-year-old Italian-born female, was admitted to the New York Hospital for the second time on April 6, 1940. Her chief complaint was shortness of breath and swelling of the ankles and abdomen for the previous four or five months.

At the age of sixteen the patient fell on her head. She was unconscious for "some time" and was "paralyzed on both sides" for the following nine months. She had a

"crooked neck" following the injury, and was said to have had lameness, weakness, and an unusual gait, all of which persisted up to the time of her death. A tonsillectomy was performed at the age of thirty-four years for recurrent sore throat.

At the time of her first admission to the hospital, in 1935, the patient complained of weakness on the right side. The patient had a brief, transient fainting spell on two occasions two days before admission. The following day she had a severe headache associated with progressive weakness and numbness of the right extremities, and some drowsiness.

On physical examination the patient was stuporous and dull, but could be aroused. A short coarse presystolic murmur was heard over the apex of the heart. There was accentuation of the first mitral and second pulmonic sounds. The heart rate was regular but rapid (110). The blood pressure was 100/80. Râles were present at both lung bases. The liver and spleen were not felt. No petechiae were present.

FIG. 1

Plaster cast of foramen magnum shows the narrowing of the passageway for the cervical cord.

FIG. 2

An atlas and an axis placed in the same relative positions as occupied by those of the patient.

Neurological examination revealed a stiff neck, a Brudzinski sign on the left, absent corneal reflex on the right, a smooth face on the right with drooping of the corner of the mouth on that side, hyperactive biceps and triceps tendon jerks on both sides, slight spasticity of the right arm with increased resistance to stretch and little or no voluntary motion, absent abdominal reflexes, hyperactive knee and ankle tendon jerks, marked bilateral patellar and ankle clonus, bilateral Babinski sign, diminished sensibility to pain in both lower extremities, loss of voluntary motion of the right lower extremity, and incontinence of both urine and faeces.

The white blood count gradually decreased from 15,600 on admission to 6,000 one month later. The temperature fell by lysis from 39.8 degrees centigrade to within normal limits two weeks later. A lumbar tap at the time of admission revealed the resting spinal fluid pressure to be 140 milimeters of water. The fluid was grossly bloody but upon centrifugation the supernatant fluid was clear. There were five lymphocytes and one polymorphonuclear leukocyte per cubic millimeter. The sugar and chloride contents were eighty and 680 milligrams per 100 cubic centimeters respectively. The Wassermann was negative.

There was gradual improvement in the patient's condition during the following two months. The weakness on the right side had not completely disappeared, however, and the patient continued to have hyperactive tendon jerks, absent abdominal reflexes, bilateral patellar and ankle clonus, and a bilateral Babinski sign. The patient was removed to her home for chronic care.

Following discharge the patient improved and was again able to be up and about, with little more disability than she had experienced prior to the recent acute episode.

Four or five months before the second admission the patient noted increasing "weakness", dyspnoea on exertion, orthopnoea, swelling of the ankles and legs late in the day, and migratory pains. These symptoms became progressively worse until the patient was completely incapacitated.

On physical examination her temperature was 37 degrees centigrade; pulse, 100; respirations, thirty-six; blood pressure, 190/140. The patient then appeared thin, emaciated, acutely and chronically ill. She was markedly orthopneic, dyspneic, and cyanotic. The cardiac signs were much the same as described on the previous admission. Distended neck veins, moist râles in the lungs, ascites, hepatomegalia, and massive oedema of the lower extremities were present. The patient's condition prevented an adequate neurological examination, but it was noted that the tendon jerks were hyperactive and the abdominal reflexes were absent.

With treatment by digitalis and mercupurin the patient's general condition improved markedly, and there was a fall of the blood pressure to more nearly normal ranges. In spite of this apparent clinical improvement, the patient died quietly on the fourteenth hospital day.

POSTMORTEM EXAMINATION

Gross Examination

There was chronic endocarditis of the mitral valve with stenosis and insufficiency. Dilatation and hypertrophy of both auricles and of the right ventricle were present. The lungs, liver, and kidneys showed the characteristic changes of chronic passive congestion. There was oedema of the lower extremities; ascites (200 cubic centimeters); and a bilateral pleural effusion (300 and 500 cubic centimeters). Old healed infarcts were present in the spleen and kidneys.

Upon opening the cranial vault there appeared to be an increased amount of subarachnoid fluid. As the brain was elevated from the floor of the cranium a

FIG. 3

A section taken through the medulla, stained for myelin sheaths.

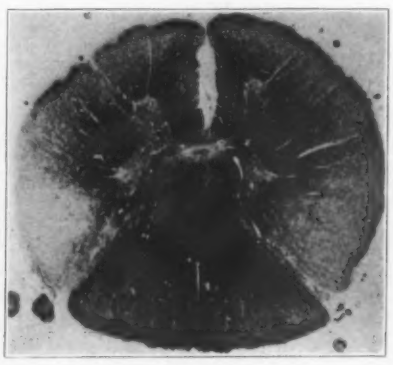

FIG. 4

A section taken through the dorsal region of the spinal cord, stained for myelin sheaths.

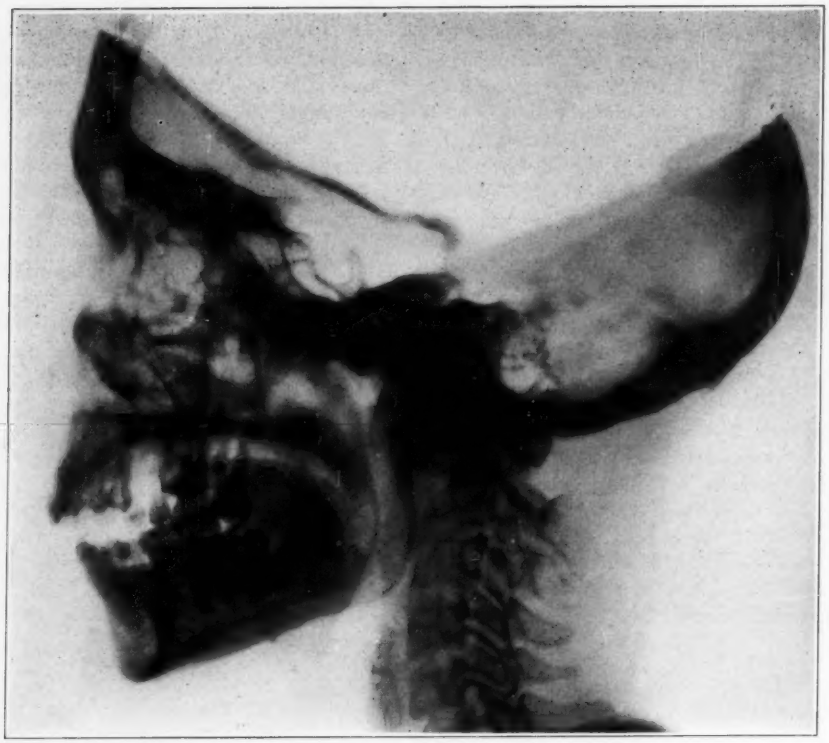

FIG. 5

Postmortem roentgenogram of skull showing the left lateral view.

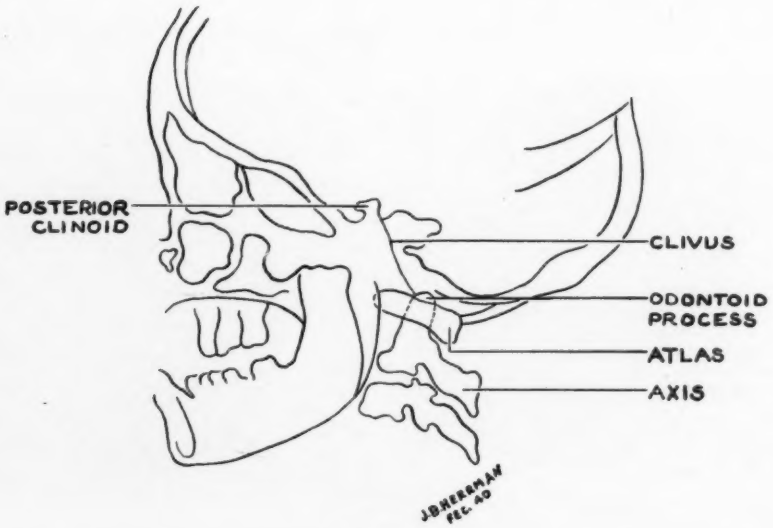

FIG. 6

Diagrammatic interpretation of Fig. 5.

FIG. 7

Postmortem roentgenogram of skull showing anteroposterior view.

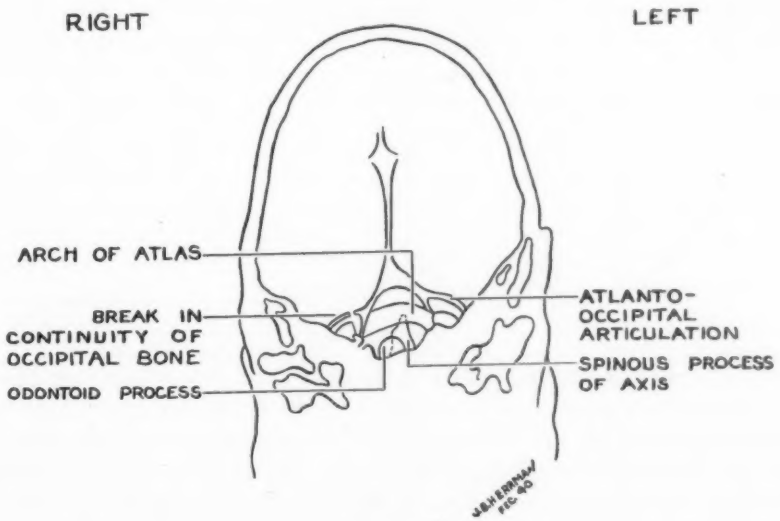

FIG. 8

Diagrammatic interpretation of Fig. 7.

deformity of the clivus and of the foramen occipitale magnum became apparent. The clivus was flattened and elevated posteriorly on the left, so that the usual downward and backward slope of 60 degrees was replaced by a slope of approximately 30 degrees. There was also a slope downward and to the right in the transverse planes. The cervical cord passed through a small slitlike space located along the right lateral border of the foramen occipitale magnum. The cord appeared to be compressed. The remainder of the foramen occipitale magnum was obliterated by what was first interpreted as a bony exostosis from the margin of the foramen and the basilar portion of the occipital bone (Fig. 1). It was thought at this point that we were dealing with a platybasia, but removal of the dura from the base of the skull revealed that this was not the case.

The foramen ovale was normal in outline but protruding up into the foramen, and pushing the dura before it so as to form a false base, was the dens of the epistropheus. Removal of a portion of the clivus gave a better view of the upper cervical vertebrae. Figure 2 illustrates the relative positions of the atlas and axis. The backward and lateral displacement of the odontoid process is apparent. This picture does not show, however, several other important facts learned from roentgenographic examination of the region, and manipulations at the time of the postmortem examination. The skull was tilted to the right and there was limitation of motion with respect to the atlas but not with respect to the remainder of the cervical spine. The postmortem roentgenograms (Figs. 5 and 7) were interpreted by John R. Carty, M.D., as follows:

"Postmortem films of the base of the skull and the upper cervical region show a slight tilting of the skull on the cervical spine to the right. The atlanto-occipital articulation on the right is narrowed and there is a break in continuity of the basal occipital bone in the immediate neighborhood. This does not extend into the bone to any extent. The atlanto-occipital joint on the left is wider than usual. There has been a crushing of the right half of the body of the atlas, with apparently some separation of the fragments. This has permitted the backward and left displacement of the odontoid process. I cannot determine definitely whether or not it has been fractured also. The findings do not suggest platybasia but seem typical of an old injury."

Examination of the brain revealed a moderate cortical atrophy with some thickening of the pia-arachnoid. In the anterior portion of the left internal capsule and in the putamen was an anaemic infarct. An early internal hydrocephalus was present.

Microscopic Examination

On microscopic examination, the lesion of the internal capsule and putamen consisted of fibrous tissue in which were many focal accumulations of gitter cells. Sections through the mid-olivary region of the medulla stained for myelin sheaths showed a marked degeneration of the pyramidal tract on the left side. The medial lemniscus and the inferior cerebellar peduncle appeared to be normally myelinated. At a slightly lower level in the medulla degenerative changes in the dorsal spinocerebellar tracts, especially on the left side, were present (Fig. 3). Sections through the thoracic portion of the spinal cord revealed a marked degeneration in both crossed pyramidal tracts, and slight degeneration in the anterolateral portions of the white matter. These changes were most marked on the left side of the cord (Fig. 4).

DISCUSSION

Unfortunately we did not have the opportunity to study this patient when her signs and symptoms referable to the cord injury were not complicated by other lesions. The neurological findings during convalescence from the lesion in the left internal capsule and the degenerative changes found at autopsy in the tracts of the cord prove, however, that the patient did have persistent bilateral pyramidal-tract lesions attributable to the injury sustained thirty years before her death. It is of interest

that the degenerative changes in the pyramidal tracts below the site of compression were greatest on the left side, even though the infarct was in the left internal capsule. The left side of the cord was in nearest proximity to the odontoid process.

Fracture of the atlas is relatively infrequent [4], but, contrary to lay opinion, is not associated with a particularly high mortality [2]. Fracture of the odontoid process, however, is characterized by a very high mortality [6]. Indeed, this is the mechanism of death by hanging. The odontoid process is held in position by a strong transverse ligament posterior to it, and it is quite unusual for the normal anatomical relation between it and the adjacent structures to be disturbed. We have no detailed information concerning the trauma in the case presented, but must necessarily assume that it was extremely severe in order to tear this transverse ligament.

The author wishes to express his sincere thanks to Drs. Bronson Ray, Lewis Stevenson, John R. Carty, and Charles Reavis for their assistance in the study of this case.

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THE MECHANICS OF THE LIGAMENTS AND MENISCI OF THE KNEE JOINT

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There is a vast amount of literature available discussing the movements of the knee joint and the function of the ligaments controlling these movements. A comprehensive review of the literature reveals no unanimity of opinion concerning the function of the knee-joint ligaments, and often equivocal statements are made. A study of the literature on this subject leaves one bewildered. Accordingly, a reinvestigation of the subject was made.

Fick [18] published an excellent discussion of all aspects of the knee joint. His work is highly recommended because of its thoroughness. He discusses at length controversial subjects and his conclusions coincide for the most part with those of the present investigation.

To discuss fully the contradictory statements with regard to ligament function would necessitate a long paper in itself; hence only a brief review of a few points of disagreement will be considered. The lateral femoral condyle acts as the axis of rotation of the knee (Campbell [5], Valls [45]). The lateral femoral condyle is not the axis of rotation (Fick [18]). Anterior gliding of the tibia on the femur is prevented by the anterior cruciate ligament, and posterior gliding of the tibia on the femur is prevented by the posterior cruciate ligament (Conwell [10], Gallie and LeMesurier [19], Saunders [40], Smith [42], Hey Groves [21], Bristow [4], Jones and Smith [27]). Pringle's discussion [37] of this function is equivocal. Horwitz and Davidson [26] believe the collateral ligaments do more to prevent anteroposterior motion than do the cruciate ligaments. The tibial collateral ligament is relaxed in flexion (Murphy [35], Steindler [43], Bennett [1], Valls [45], McMurray [33]). The tibial collateral ligament, or some portion of it, remains taut in all positions of extension or flexion (Mauck [31], Horwitz [25], Fick [18]). Lateral stability—abduction or adduction of the tibia on the femur—is maintained by the collateral ligaments, the cruciate ligaments, and the menisci (Kreuscher [28], Smith [42]). Abduction of the tibia on the femur tears the tibial collateral ligament, and adduction of the tibia on the femur tears the fibular collateral ligament (Bristow [4], Campbell [7]). Removal of either or both menisci when injured or diseased is the general practice, and a stable knee is obtained (Shands, Hutchinson, and Ziv [41], Chandler [8], Henderson [22], Kreuscher [28], Bristow [4], Bennett [2], etc.).

The cruciate ligaments are the important stabilizers of the knee

(Hey Groves [20], Gallie and LeMesurier [19], Smith [42], Bristow [4]). Cruciate ligaments are vestigial structures (Herzmark [23]). The collateral ligaments are the main stabilizers of the knee joint (Conwell [10], Ryerson [39], Horwitz [25], Bennett [1]). The tibial collateral ligament is the most important ligament of the knee (Milch [34]). Rupture of the anterior cruciate ligament results in no instability (Darrach [16], Saunders [40], Milch [34]). Rupture of the cruciate ligaments gives a permanently disabled knee (Hey Groves [20]). Rupture of the posterior cruciate ligament invariably gives an unstable knee (Gallie and LeMesurier [19]). The anterior cruciate ligament is taut in extension, and the posterior cruciate ligament is taut in flexion (Bennett [1], Jones and Smith [27]). Both cruciate ligaments are taut in extension (Saunders [40]). Some portion of both cruciate ligaments is tense in all positions of extension or flexion (Fick [18]). The anterior and posterior cruciate ligaments are taut in extension and complete flexion, but are relaxed in semiflexion (Smith [42]). According to Steindler [43] and Fick [18], the greatest amount of capsule distention is at 20 to 30 degrees of flexion, while Mayer and Burman [32] lead one to believe this is not true.

If the importance of function of knee-joint ligaments can be based on the clinical necessity of repair, there is considerable controversy. If ruptured collateral ligaments are repaired, ruptured cruciate ligaments seldom need to be repaired (Dickson and Lawrence [17], Cotton and Morrison [11], Bosworth and Bosworth [3], Henderson [22], Mauck [30], Ryerson [39], Darrach [16], Horwitz and Davidson [26], Bennett [1]). Repair of ruptured cruciate ligaments is usually necessary (Cubbins, Conley, Callahan, and Scuderi [15], Cubbins, Callahan, and Scuderi [12, 13, 14], Campbell [6, 7], Strickler [44], Lee [29], Hey Groves [20, 21], Gallie and LeMesurier [19], Mayo Robson [38], Smith [42], Pringle [37]). It is important to repair the collateral and cruciate ligaments if ruptured (Campbell [7], Smith [42], Hey Groves [21]). It would seldom be necessary to repair the collateral ligaments, since repair would be natural, if proper protection were given to the acutely injured knee (Bristow [4]). Many other discrepancies could be given.

METHODS AND MATERIAL OF INVESTIGATION

In the course of a study of approximately 100 knee joints, observations have been made which seem to offer some clarification of the functional rôle of the ligaments of the knee joint, and tend to settle some of the moot points mentioned.

Many of the joints were obtained from thigh amputations, and were studied in the fresh condition, while others were secured from embalmed cadavera.

The joints were dissected in every conceivable manner with special reference to the capsule and ligaments. Tests of function and motion were made in fresh and preserved joints stripped of all parts except the ligaments. Individual ligaments and combinations of ligaments were cut, and the function of the ligaments and motion of these joints were

studied. Joints were split in different planes, and the bone configuration changed to bring into view the ligaments and their activities. The joint cavity was injected, and frozen cross sections were made. The result of cutting individual ligaments and combinations of ligaments was studied in fresh intact knee joints. Microscopic studies were made of the tibial collateral ligament and medial meniscus.

A duplication of injuries by forced tearing of ligaments or capsule (Pringle [37], Horwitz and Davidson [26], Hönigschmied [24], Pagenstecker [36]), was not attempted because, in the absence of muscular support, force could not be applied in a manner which would duplicate the forces which cause injury in the living subject.

In order to measure more accurately the degree of lateral motion —abduction and adduction of the tibia on the femur—a simple apparatus was devised. A vice was solidly set into a piece of timber. Upright bars with pulleys were made fast to the timber at different levels and positions. The femur was fixed in the vice and a wooden piece fixed to the tibia. By means of a pointer the movements of the tibia could be measured. Lateral and rotary force then could be applied to the tibia under set conditions by suspending weights from the tibia by means of a cord over the upright bars and pulleys. The bars were in different positions to allow the force to be applied on a horizontal plane. For lateral motion a weight of 3.5 kilograms was suspended from the tibia, 10 centimeters distal to the articular surface. By the same method of force application the joint was held in extension—really hyperextension—by a weight of 2.1 kilograms while lateral motion was measured as stated above. For rotation a weight of 2.1 kilograms was suspended 10 centimeters distal to the tibial articular surface on a 7-centimeter lever arm. There was one degree of error in the apparatus. While in extension both lateral and rotary motions could be very accurately measured, but difficulty was encountered in consistently maintaining exactly 90-degree flexion or full flexion. This difficulty probably accounts for inconsistencies in Table I where occasionally, after cutting a ligament, less motion, by a few degrees, was noted. In a stripped joint it is almost impossible to determine accurately the neutral position. Accordingly, the degree of lateral motion is not divided into medial and lateral rotation. [Unfortunately, this is a recent part of the experiment and has been carried out on only twenty-three joints (Table I).]

The figures used in the text are the results of observations on all joints studied, including those measured. There is considerable variation in motion from joint to joint, which makes average figures seem inconsistent when applied to an individual joint.

By a fresh joint is meant one recently amputated and studied without preserving. The joints were kept in the ice box until the study was over, and then were discarded or put in formalin for future reference. To avoid repetition, the statement "fresh intact joint" will mean a fresh joint without anything removed, not even the skin. A "stripped joint"

will indicate a joint with all structures removed down to and including the capsule, but with the ligaments and menisci of the knee joint intact. Lateral motion will mean abduction or adduction of the tibia on the femur, and rotation will mean pronation or supination of the tibia on the femur.

In the fresh joint the ligaments are stronger and more resilient than in the preserved, and, therefore, the motion and function are more nearly normal. Joints preserved in formalin show less lateral and rotary motion than do fresh joints; however, joints obtained from embalmed anatomical cadavera allow more lateral and rotary motion than do the fresh joints.

MOTION OF THE NORMAL KNEE JOINT

In a completely extended knee joint both collateral (Figs. 2*a* and 9*a*) and cruciate (Fig. 12*a*) ligaments are taut, and the anterior aspects of both menisci (Fig. 10*b*) are snugly held between the condyles of the tibia and the femur. The greater the hyperextension, the tighter are these ligaments, and the tighter are held the anterior aspect of the menisci. In the first few degrees of flexion, there is a medial rotation of the tibia on the femur of about 1 to 3 degrees. As flexion continues, the fibular collateral ligament relaxes (Figs. 5*a* and 9*b*) and remains relaxed even in full flexion. The tibial collateral ligament remains taut throughout flexion, but the area of tension is changed from the whole width of the ligament in extension to the anterior portion of its fibers while in complete flexion. The posterior portion of the ligament is then relaxed (Fig. 2). The tibial collateral ligament slides posteriorly on the surface of the tibia with flexion, and its midportion slides from a few millimeters to one centimeter when the joint moves from complete extension to full flexion (Fig. 2). Both cruciate ligaments remain taut throughout flexion and more stress is placed on them in full flexion (Fig. 12). Accordingly, the three ligaments, tibial collateral and both cruciates, remain taut, but not tense, throughout flexion. They are somewhat more taut from about 80 to 100 degrees of flexion. Both menisci slide backward with flexion. Often the medial meniscus moves only a few millimeters backward while the lateral one moves at least one centimeter. In full flexion the posterior aspect of both menisci are snugly pressed between the condyles of the tibia and the femur (Fig. 10*a*).

Since in full extension or hyperextension both collateral and cruciate ligaments are tense, practically no lateral motion or rotation is present (Table I). In flexion with relaxation of the fibular collateral ligament (Fig. 3) there is a variation in rotation of 6 to 24 degrees in fresh intact joints (Table I). The tibia rotates on the femur more in the lateral than in the medial direction. The tibial collateral ligament and both cruciate ligaments remain taut in all positions of flexion but not tense as in complete extension, thus allowing some lateral motion in flexion; the greatest amount of lateral motion is allowed between 30 and

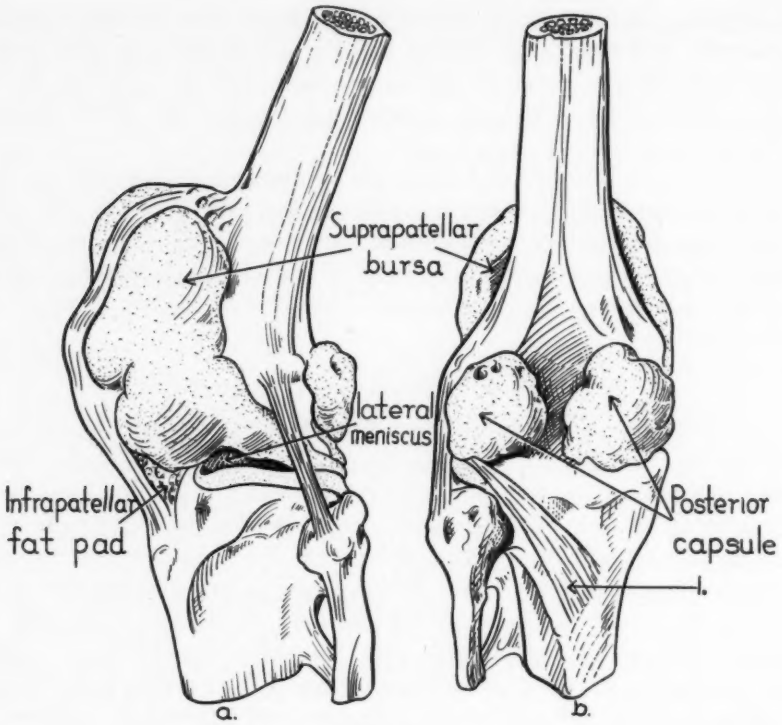

FIG. 1

A mold of a normal distended joint cavity.

A fresh intact joint was injected with dental plaster under slight pressure. The plaster hardened and the joint was stripped of all tissue but ligaments and menisci. The plaster mold represents a normal distended knee-joint cavity and the extent of the synovial membrane. The infrapatellar pad of fat is outside the joint cavity and synovial membrane which stops short at the upper end of the tibia, but extends for a considerable distance over the femur as the suprapatellar bursa. The collateral and cruciate ligaments and the menisci are actually outside the synovial membrane. Posteriorly, the joint capsule and synovial membrane cover the posterior aspect of the femoral condyles individually.

1: Partially removed popliteus muscle and its tendon.

50 degrees of flexion. [At 90 degrees' flexion there is a variation of 4 to 9 degrees of lateral motion in fresh intact joints (Table I).]

The rotation of the femur on the tibia as the joint comes into or leaves complete extension is controlled by the bone architecture of the joint as well as its ligamentous arrangement. The articular surface of the medial femoral condyle is larger than that of the lateral femoral condyle (Fig. 11*a*). In the beginning of flexion the lateral femoral condyle rolls backward considerably farther on the lateral tibial plateau than does the medial femoral condyle on the medial tibial plateau. The greater backward displacement of the lateral meniscus is direct evidence of this. The medial meniscus moves backward very little. The greater backward displacement of the lateral femoral condyle indicates the rotation of the femur; accordingly, the axis of rotation of the knee must be near

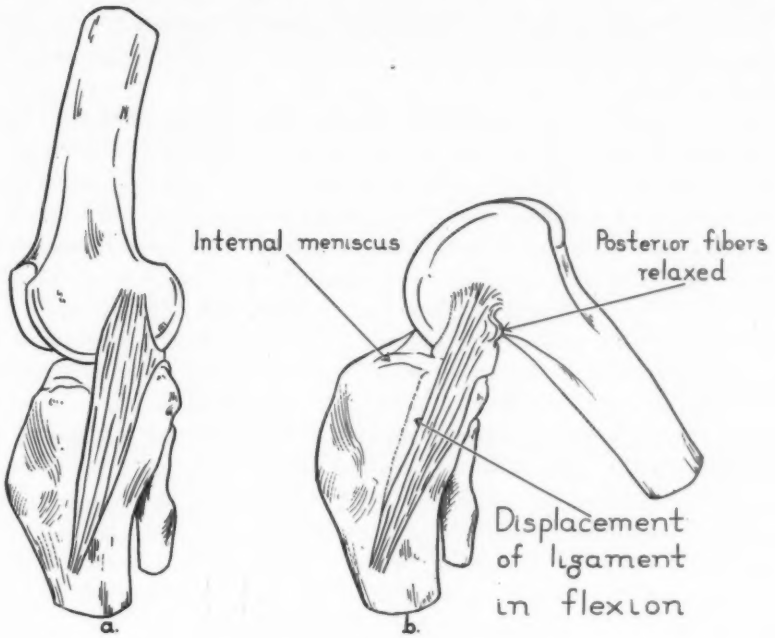

FIG. 2

A stripped joint showing tibial collateral ligament.

a: Tension on the tibial collateral ligament is distributed throughout its width in extension.

b: In flexion the area of tension is shifted to the anterior portion of its fibers while the posterior portion is relaxed. Some portion of the ligament is taut in every position. The sliding of the ligament backward in flexion and forward in extension is indicated.

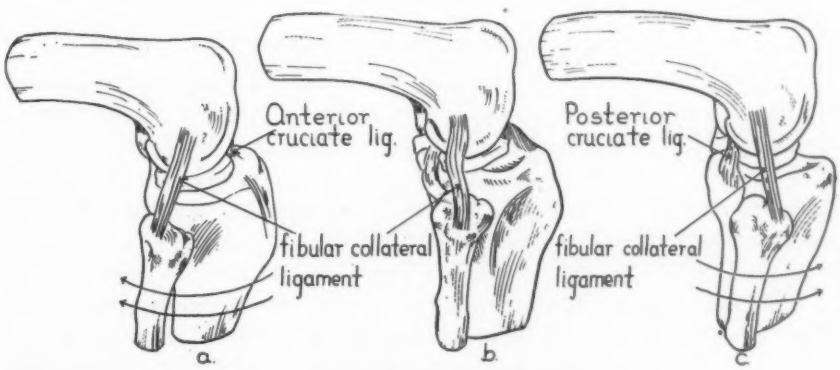

FIG. 3

The lateral aspect of a stripped joint revealing normal medial and lateral rotation. Rotation is normally possible in a flexed knee joint.

a: On lateral rotation of the tibia on the femur the fibular collateral ligament tightens.

b: In the normal position with neither lateral nor medial rotation, the fibular collateral ligament is relaxed.

c: On medial rotation of the tibia on the femur the fibular collateral ligament again tightens. Normal rotation of the tibia on the femur in flexion would not be present if the fibular collateral ligament were not relaxed.

the medial femoral condyle. Greater freedom of motion of the lateral femoral condyle is allowed by the relaxation of the fibular collateral ligament (Fig. 3).

In twenty-five knee joints the tibial collateral ligament was measured from the articular surface of the tibial condyle to the attachment of the ligament to the tibia. The greatest distance was 5.7 centimeters; the shortest, 3.8 centimeters; and the average, 4.6 centimeters. In measuring from the articular surface of the tibial condyle to the distal end of the tibial collateral ligament, the greatest length was 9.5 centimeters; the shortest, 6.4 centimeters; and the average, 7.8 centimeters. The sliding of the tibial collateral ligament forward and backward in extension and flexion (Fig. 2) occurs because the anterior bone attachment of the ligament is distal to the tibial articular surface. The posterior aspect of the ligament is attached to the tibia immediately superior and lateral to the insertion of the semimembranosus muscle. This attachment limits the anterior progress of the ligament in extension, and its relaxation in flexion permits the posterior gliding of the ligament. There is close approximation of this ligament to the medial meniscus, but not a fixed immovable fibrous attachment (Fig. 13). The medial meniscus moves forward in extension and backward in flexion, but not to such a great extent as the tibial collateral ligament. The statements just made are not obvious in preserved specimens, but are readily demonstrated in fresh joints. That the ligament does not have a bone attachment to the tibia throughout its whole distance over the tibia is evident because the inferior medial genicular artery courses between the ligament and the tibia, and often a bursa is interposed between the ligament and the bone.

LATERAL MOTION OF THE KNEE JOINT

In the discussion of lateral motion any abnormal rotation which may be present will be neglected. In a stripped preserved joint there is practically no lateral motion in complete extension. In flexion there are a few degrees of lateral motion which is greatest between 30 and 50 degrees of flexion. With fresh intact joints there is a variation of 2 to 5 degrees of lateral motion in complete extension, and 4 to 9 degrees in 90-degree flexion (Table I). When either (Figs. 4*a* and 4*b*) or both (Fig. 6*a*) collateral ligaments are cut, there is practically no change in the lateral motion if both cruciate ligaments are intact. When both collateral ligaments are intact and either anterior or posterior cruciate ligament is cut, there is no change in lateral motion. If, however, both cruciate ligaments are cut and both collateral ligaments are intact (Fig. 4*c*), there is no abnormal lateral motion in extension, but there is abnormal lateral motion in flexion because then the fibular collateral ligament is normally relaxed (Figs. 5*a* and 5*b*). Abnormal motion present when other combinations of ligaments are cut can be seen by referring to Table I.

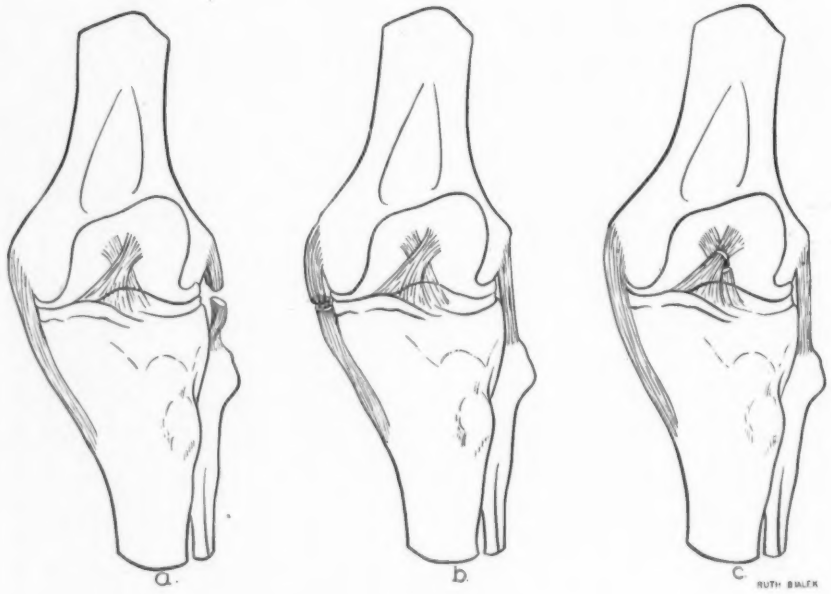

FIG. 4

A stripped joint in extension with various ligaments cut.

a: There is no abnormal lateral motion when only the fibular collateral ligament is cut.

b: There is no abnormal lateral motion when only the tibial collateral ligament is cut.

c: With the joint extended there is no abnormal lateral motion when both cruciate ligaments are cut and both collateral ligaments are intact (See Fig. 5).

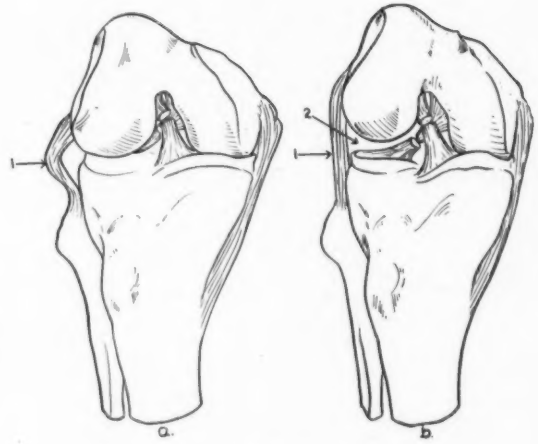

FIG. 5

A stripped joint in flexion with both cruciate ligaments cut and both collateral ligaments and menisci intact.

a: There is relaxation of the fibular collateral ligament (*1*).

b: There is an abnormal amount of lateral motion present (*2*). (Compare with Fig. 4*c* where there is no relaxation of the fibular collateral ligament in extension and no abnormal lateral motion; and with Fig. 12 where tautness of the cruciate ligaments in all positions prevents lateral motion in flexion when the collateral ligaments are cut.)

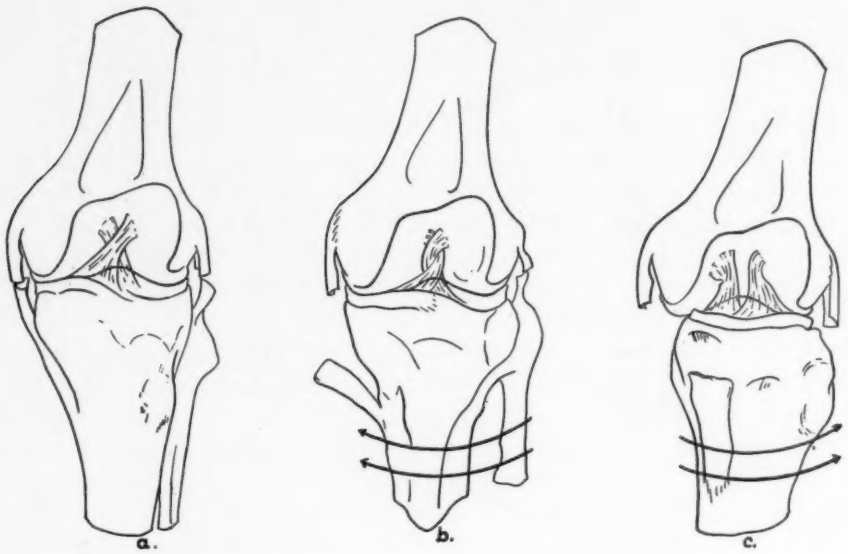

FIG. 6

A stripped joint with both collateral ligaments cut and both cruciate ligaments and menisci intact.

a: There is no abnormal lateral motion of the joint. (This is also true in flexion.)

b: Very little abnormal medial rotation of the tibia on the femur is possible because the cruciate ligaments twist on themselves.

c: Free lateral rotation of the tibia on the femur is possible because the cruciate ligaments untwist in this motion.

In fresh intact joints, when all ligaments are cut, there is a variation of lateral motion of 2 to 11 degrees in extension, 12 to 32 degrees in 90-degree flexion, and 10 to 32 degrees in full flexion (Table I). Reference to Table I will reveal that removal of one or both menisci does not materially change lateral motion. Lateral motion is increased somewhat if rotation is permitted.

Lateral motion of the knee joint in extension is controlled by the capsule, both collateral, and both cruciate ligaments; in flexion it is controlled by the capsule, tibial collateral, and both cruciate ligaments (the fibular collateral is relaxed). (In the living the muscles and tendons about the knee aid in lateral stability.)

ROTARY MOTION OF KNEE JOINT

In the discussion of rotary motion any abnormal lateral motion which may be present will be neglected. In a stripped preserved joint there is practically no rotation in complete extension, but in flexion there is present some rotation (Table I); in the fresh intact joints, the rotation varies from 6 to 24 degrees in the 90-degree position and 4 to 21 degrees in full flexion. Relaxation of the fibular collateral ligament in flexion allows this normal rotation in flexion (Fig. 3). When the tibial collateral ligament is cut, there is no rotary change while in extension, but

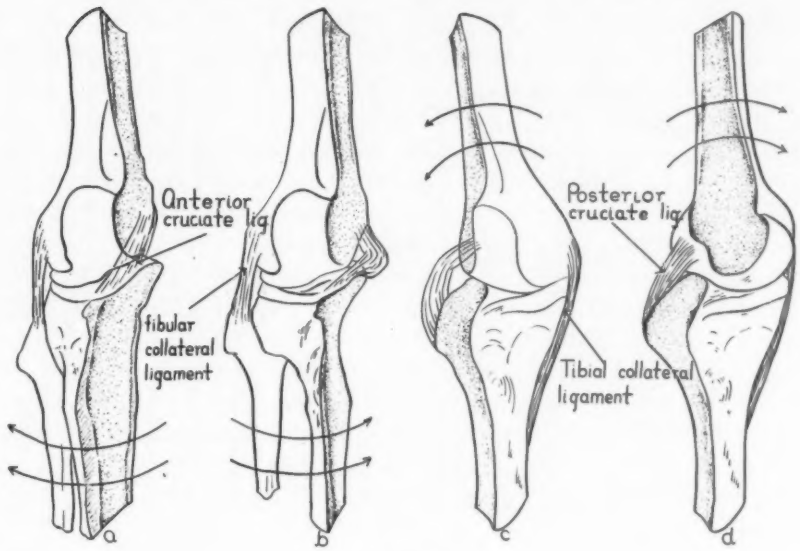

FIG. 7

Two halves of a stripped split joint. In the lateral half of the joint (*a* and *b*), the fibular collateral and anterior cruciate ligaments are intact; in the medial half of joint (*c* and *d*), the tibial collateral and posterior cruciate ligaments are intact.

a: Lateral rotation and anterior gliding of the tibia on the femur are not possible because the pull is in the direction of the attachment of the anterior cruciate ligament.

b: Medial rotation of the tibia on the femur is possible because it relaxes the anterior cruciate ligament, and gliding of the tibia posteriorly on the femur is possible for the same reason.

c: Medial rotation and forward gliding of the tibia on the femur are possible because this motion relaxes the posterior cruciate ligament.

d: Lateral rotation and backward gliding of the tibia on the femur are impossible because the pull is in the direction of the attachment of the posterior cruciate ligament.

in flexion there is about double the normal amount of rotation present (Table I). When the fibular collateral ligament is cut, there is practically no abnormal rotary change in the position of extension or flexion. When the posterior cruciate is cut, there is no rotary change while in extension, but in flexion the amount of rotation is increased (Table I). This is also true for the anterior cruciate ligament. When both cruciate ligaments are cut, there is practically no rotary change in extension, but the rotation while in flexion is three times greater than normal (Table I). When both lateral ligaments are cut, there is present external rotation of about 180 degrees or more in either the extended or flexed position (Fig. 6). It is important to point out, however, that this abnormal rotation is lateral rotation of the tibia on the femur coincidental with the untwisting of the cruciate ligaments (Fig. 6*c*). There is practically no abnormal medial rotation of the tibia on the femur because the cruciate ligaments tend to twist on themselves (Fig. 6*b*); thus the cruciate ligaments alone can control internal rotation of the tibia on the femur.

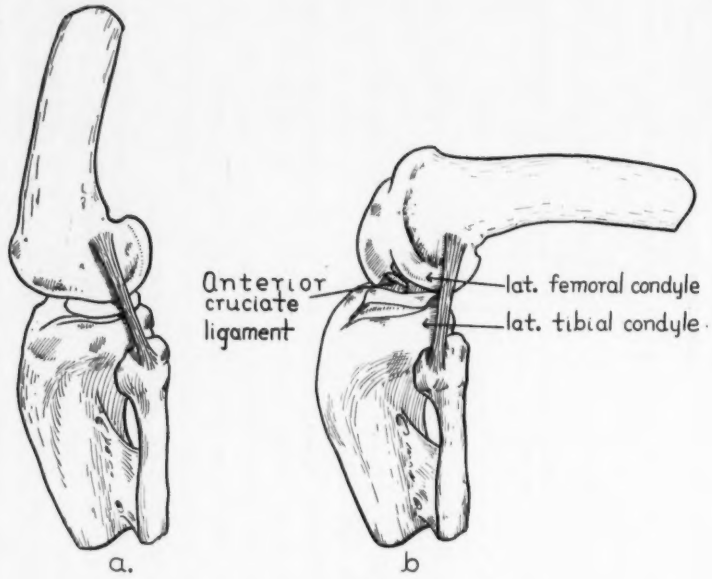

FIG. 8

A stripped joint with anterior cruciate ligament cut.

When the anterior cruciate ligament is cut, the lateral femoral condyle tends to roll off the lateral tibial condyle and the tibia rotates medially. (Relaxed fibular collateral ligament in flexion allows this.) The medial femoral condyle does not tend to roll off the medial tibial condyle.

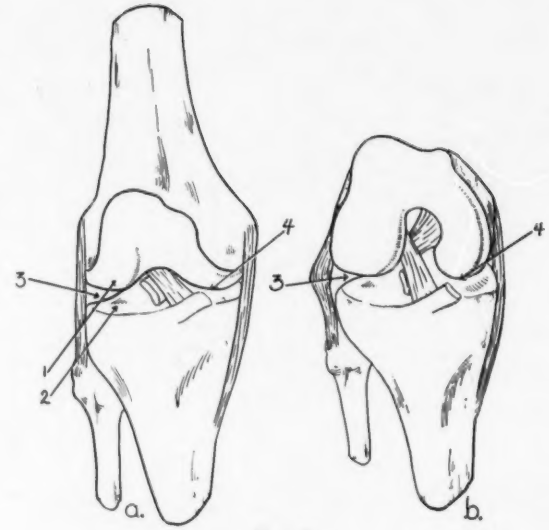

FIG. 9

A stripped joint with both menisci removed; *a:* in extension, and *b:* in flexion.

Note that the medial curved intercondyloid surface of the lateral femoral condyle (*1*) is in contact with the intercondyloid eminence of the lateral tibial condyle (*2*). There is a wide distance separating the articular surfaces of the lateral tibial and the lateral femoral condyles at the periphery (*3*). The medial femoral and tibial condyles have a wider articulating surface (*4*); the medial condyle of the femur is in contact with the intercondyloid eminence of the tibia. The femoral intercondylar space fits snugly over the intercondyloid eminence of the tibial condyles and prevents lateral gliding of the tibia on the femur.

When a stripped joint is split there are two workable halves (Fig. 7). The lateral half has the fibular collateral and anterior cruciate ligaments intact, and the medial half has intact the tibial collateral and posterior cruciate ligaments. When the lateral half is in extension, there is no abnormal lateral rotation because such motion pulls in the direction of the attachment of the anterior cruciate ligament (Fig. 7*a*); however, in flexion there is abnormal lateral rotation because the fibular collateral ligament is relaxed. In the medial half of the joint there is no abnormal lateral rotation of the tibia on the femur in either extension (Fig. 7*d*) or flexion, because the pull is exactly in the direction of the attachment of the posterior cruciate ligament. There is abnormal rotation in the medial direction, however, in both halves, because this motion relaxes the cruciate ligaments (Fig. 7*b* and 7*c*). This reveals that the cruciate ligaments, working in association with the collateral ligaments, help control lateral rotation of the tibia on the femur. Reference to Table I will reveal rotary changes that occur when other combinations of ligaments are cut. Removal of one or both menisci does not materially change the rotary stability of the joint (Table I).

In the fresh intact joints, when all ligaments are cut, there is a variation of rotary motion of 4 to 25 degrees in extension, 22 to 42 degrees in 90-degree flexion, and 10 to 33 degrees in full flexion (Table I).

Rotary stability of the knee joint in extension is controlled by the capsule, both collateral, and both cruciate ligaments; in flexion, by the capsule, tibial collateral, and both cruciate ligaments (the fibular collateral ligament is relaxed).

BACKWARD AND FORWARD GLIDING OF THE TIBIA ON THE FEMUR

In the study of forward and backward gliding of the tibia on the femur other abnormal motions will be omitted. There is no demonstrable forward or backward motion when the preserved or fresh stripped joint is intact. In the stripped preserved joint, when the posterior cruciate ligament is cut, there is only a millimeter or two of backward gliding of the tibia on the femur in extension, but this is increased in flexion. Extension and flexion of the joint are practically normal. When the anterior cruciate ligament is cut, there is only a millimeter or two of forward gliding of the tibia in extension, but in flexion this is increased about three times. In such a joint extension is normal, but in full flexion the lateral femoral condyle tends to roll completely off the lateral tibial condyle (Fig. 8). (One cadaver specimen revealed an old rupture of the anterior cruciate ligament, and this joint showed the same findings.) The lateral femoral condyle is allowed to roll off the lateral tibial condyle because the fibular collateral ligament is relaxed in flexion (Fig. 5*a*). Of course, this would not occur if the capsule were intact. In extension when both cruciate ligaments are cut and both collateral ligaments are intact, the gliding forward and backward of the tibia on the femur is about

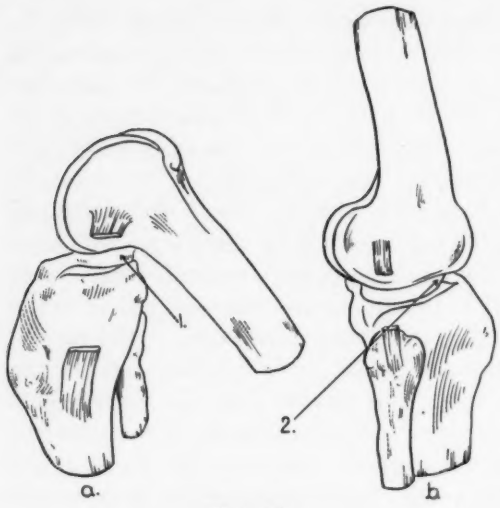

FIG. 10

A stripped joint showing the relationship of the menisci to the condyles in full flexion (*a*) and complete extension (*b*). The collateral ligaments in the drawings were removed for clarity but were intact in the joint tested.

a: In hyperflexion the posterior aspect of the medial meniscus acts as a cushion between the femur and the tibial condyle (*1*). (A drawing of the lateral meniscus would reveal the same condition.)

b: In hyperextension the anterior aspect of the lateral meniscus is snugly held by the lateral condylar notch and the tibial condyle, thus acting as a cushion (*2*). (A drawing of the medial meniscus would reveal somewhat the same condition.)

5 to 6 millimeters. This small amount of motion is due to the definite tightening of the collateral ligaments in complete extension. In flexion the forward and backward gliding amounts to about 10 to 12 millimeters, and the lateral femoral condyle again tends to roll off the lateral tibial condyle. Greater forward and backward gliding is not present in the preserved joint, because the tibial collateral ligament is more intimately attached to the tibia and medial meniscus by the hardening of the intervening areolar tissue by the fixing solution; thus the tibial collateral ligament does not slide on the tibia as it does in the fresh joint. Accordingly, the tibial collateral ligament prevents excessive forward and backward gliding of the medial side of the tibia on the femur in preserved joints, but not in fresh joints. In the stripped fresh joint with both cruciate ligaments cut and both collateral ligaments intact, the amount of forward and backward gliding in extension depends considerably on the force of hyperextension, but in flexion there is about 1.5 to 2.0 centimeters. The attachment of the posterior aspect of the tibial collateral ligament to the posterior surface of the tibia limits the forward and backward gliding of the medial tibial condyle on the femur when the joint is in extension. However, in flexion the posterior portion of the tibial collateral ligament is relaxed and therefore exerts no control over this motion. (If rotation is permitted, the anterior and posterior gliding appears greater.) In the intact fresh joint with both cruciate ligaments cut, it is difficult to measure accurately the amount of forward and backward motion, but it corresponds quite well with the findings stated. However, the rolling of the lateral femoral condyle off the lateral tibial condyle, when the anterior cruciate ligament or both cruciate ligaments are cut, is not noticeable, as this is prevented by the capsule and soft structures. When all ligaments are cut, there is a variable amount of forward and backward motion, usually about 2.5 centimeters in flexion.

The anterior cruciate ligament prevents forward gliding of the tibia on the femur because such force is directed in the line of the attachment of the anterior cruciate ligament (Fig. 7*a*). The posterior cruciate ligament prevents backward gliding of the tibia on the femur because such force is directed in the line of attachment of the posterior cruciate ligament (Fig. 7*d*).

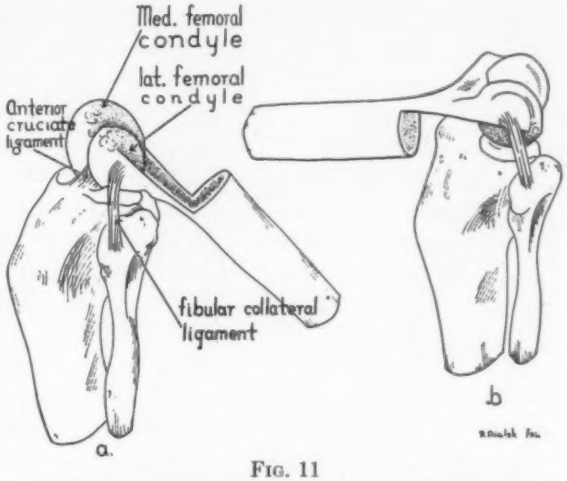

FIG. 11

A stripped joint with all ligaments and menisci intact but with the patellar surface of the femoral condyles removed.

a: The joint is in normal full flexion.

b: The joint will move into slightly more than 90-degree hyperextension. Note the femoral condyles are elliptical in outline and the medial femoral condyle is almost twice as large as the lateral femoral condyle. Ligament control and tension are unchanged.

Since the anterior and posterior cruciate ligaments are taut in all positions of extension and flexion (Fig. 12), they are very important in maintaining the exact normal anatomical relationship between the tibial and femoral condyles.

Reference to Table I will indicate that the tibial collateral and anterior cruciate ligaments probably add greater stability to the knee joint than do the fibular collateral and the posterior cruciate ligaments.

LATERAL GLIDING OF THE TIBIA ON THE FEMUR

The possibility of lateral gliding of the tibia on the femur can be dismissed with a few words about the bone architecture of the condyles. The intercondyloid eminence of either tibial condyle so fits in the curved articular surface of the intercondyloid fossa of the femur that definite bone contact prevents any lateral gliding in either direction (Fig. 9). Of course, with ligaments cut allowing excessive lateral motion, this bone structure is obviated.

HYPEREXTENSION AND HYPERFLEXION

In the stripped joint both collateral (Figs. 2*a* and 9*a*) and cruciate ligaments (Fig. 12*a*) are taut in complete extension, and the anterior aspects of the menisci (Fig. 10*b*) are held snugly in the notches of the medial and lateral femoral condyles. As hyperextension is attempted, all four ligaments become very tense; and the anterior aspect of both menisci becomes definitely compressed between the femoral and tibial condyles. The architecture of the femoral condyles, and to a lesser degree the attachment of the ligaments, brings this about. The portions

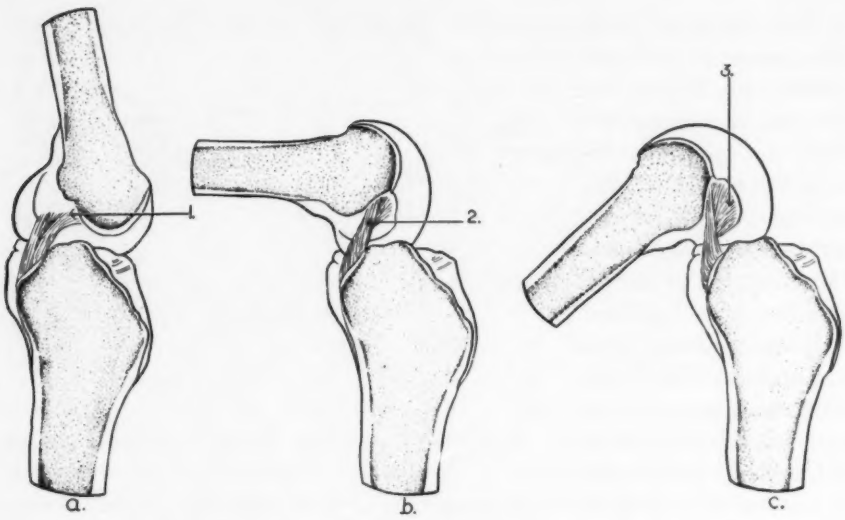

FIG. 12

The split surface of the medial half of a split, stripped joint. The tibial collateral and posterior cruciate ligaments are intact. The manner of attachment and the rolling of the posterior cruciate ligament keep some portion of it taut in all positions of extension and flexion.

a: The posterior cruciate ligament prevents hyperextension, with the greatest stress on the fibers of the posterior position. The attachment (*1*) of this ligament to the femur is horizontal to the joint in extension.

b: Partial flexion shows smoothly changing tension from the posterior to the anterior fibers as the ligament rolls upon itself (*2*).

c: The posterior cruciate ligament prevents hyperflexion, with greatest stress on the anterior fibers. Its attachment to the femur is vertical to the joint in full flexion (*3*).

(A similar view of the lateral half of a split joint would show essentially the same features for the anterior cruciate ligament.)

of the femoral condyles that are in relation to the tibial condyles have definitely a smaller curve than the portions that are in relation to the patella. This abrupt change in the curve of the condyles wedges the tibial portion of the femoral condyles away from the tibial condyles, thus attempting to lengthen the distance between the attachments of the ligaments. The medial and lateral femoral condylar grooves, being most prominent on the lateral condyle, aid in holding the menisci from gliding farther forward (Fig. 10*b*).

When the femoral condyles are cut away and the ligaments left intact (Fig. 11), the joint will go into more than 90 degrees' hyper-extension. The femoral condyles cut in such a manner are elliptical in contour.

As the joint is flexed, the fibular collateral ligament relaxes and remains so even in complete flexion. The tibial collateral ligament shifts its tension from the whole width of the ligament to the anterior fibers, but some portion remains taut in all degrees of flexion (Fig. 2).

It can be shown on either half of the split stripped joint that both the anterior and posterior cruciate ligaments remain taut throughout all degrees of flexion and become definitely tense when hyperextension is attempted (Fig. 12*c*).

When an x-ray of a living knee joint in full forced flexion is compared with a stripped joint in full flexion, the stripped joint has about 10 to 15 degrees more flexion. In the stripped joint full flexion finally is limited by the bone portion of the femur above the condyles coming in apposition with the tibial condyles and being cushioned by the posterior aspects of the menisci (Fig. 10*a*). In the intact joint as well as in the living joint the femoral attachment of the posterior aspect of the capsule and the femoral attachment of both heads of the gastrocnemius muscle act with the menisci as a cushion, limiting hyperflexion.

Approximately twelve attempts were made to dissect a joint down to the capsule, leaving the capsule intact. This could not be accomplished on the anterior and anterolateral aspect of the joint, but could be easily accomplished on the posterior aspect. Anteriorly, the capsule could always and easily be demonstrated from the periphery of the tibial articular surface to the menisci, but above the menisci it blended with tendons and deep fascia of the extremity in such a way that it was always lost. The patellar tendon, patella, and quadriceps tendon replace the capsular structure in their respective regions.

In hyperextension the posterior aspect of the capsule and the oblique popliteal ligament are tense. In hyperflexion the capsule apparently takes no part in checking the motion.

Hyperextension is checked by both collateral ligaments, both cruciate ligaments, the posterior aspect of the articular capsule, the oblique popliteal ligament, the anterior aspect of the menisci, and especially the architecture of the condyles of the femur.

Hyperflexion is checked by both cruciate ligaments, the posterior aspect of the menisci, the femoral attachment of the posterior aspect of the capsule, the femoral attachment of the gastrocnemius muscle, and the bone architecture of the femur. The cruciate ligaments are most important. (In the living, muscle action will have much to do with checking both hyperextension and hyperflexion.)

THE MENISCI

The motion of the menisci has been discussed. Their cushioning effect in hyperextension and full flexion was noted. The lateral meniscus is smaller in diameter, thicker about the periphery, and usually wider than the medial. In addition to its strong bone attachment, it is attached to the anterior cruciate ligament in front and the posterior cruciate ligament behind by strong fibrous tissue. (When present, the ligament of Wrisberg attaches the lateral meniscus to the femur.) It is separated from the fibular collateral ligament by the popliteus tendon. The medial meniscus is much larger in diameter, thinner about the periphery, usually narrower, and has no fibrous attachment to either cruciate ligament. It is closely related to the tibial collateral ligament, but only by areolar tissue. There is no strong fibrous attachment between the tibial collateral ligament and the medial meniscus (Figs. 13 and 14), and often a bursa is interposed.

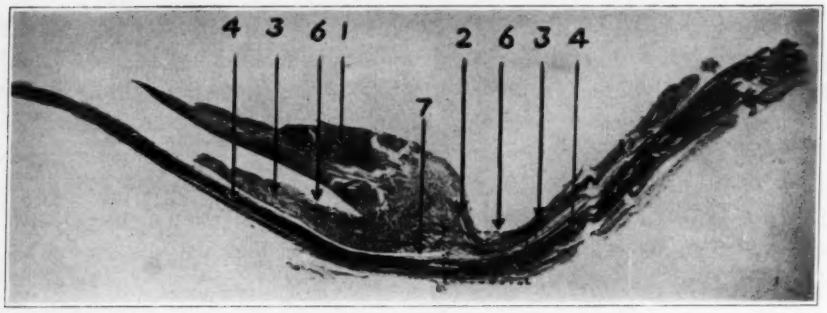

FIG. 13

Photomicrograph of the medial meniscus and tibial collateral ligament. In gross dissection of fresh knee joints the tibial collateral ligament can be stripped from the medial meniscus with the handle of the scalpel. A block of tissue was taken from each of six fresh joints, removing a portion of the tibial collateral ligament with a corresponding portion of the medial meniscus. Sections were made parallel with the fibers of the tibial collateral ligament approximately through its center.

1 shows the medial meniscus; *2*, the junction of the capsule of knee joint and the meniscus revealing fibrous tissue attachment; *3*, true capsule of knee joint; *4*, tibial collateral ligament; *6*, synovial membrane; and *7*, bursa. The area enclosed by dotted lines is shown in higher magnification in Fig. 14.

The fibrous tissue of the true capsule of the knee joint blends intimately with the menisci about the periphery (Fig. 13). The lateral meniscus, however, is separated from the capsule where the popliteus tendon enters the joint. The circle enclosed by the medial meniscus is several times larger than the circle enclosed by the lateral meniscus. A study of the circles enclosed by the two menisci reveals that the articular surface of

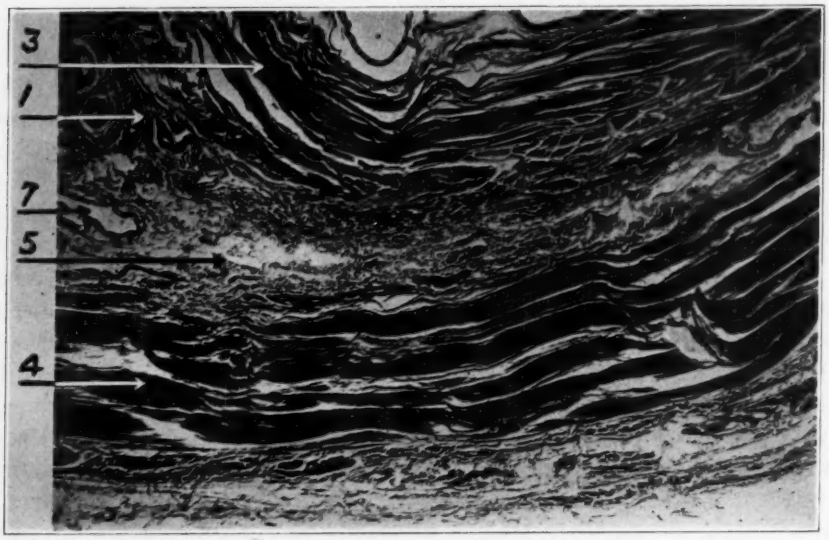

FIG. 14

Photomicrograph of section taken from Fig. 13. *1* indicates the medial meniscus; *3*, the true capsule of knee; *4*, the tibial collateral ligament; *5*, areolar tissue between the medial meniscus and the tibial collateral ligament; and *7*, the bursa with its lining membrane.

the medial femoral condyle is in apposition with the tibial condyle over a rather broad area adjacent to the medial intercondyloid eminence (Fig. 9), while the lateral femoral condyle is in apposition with the tibial condyle over a very small area adjacent to the lateral intercondyloid eminence; thus leaving a large area about the periphery of the lateral tibial and femoral condyles rather wide apart (Fig. 9). This, of course, is evident because the lateral meniscus about the periphery is thicker than the medial.

This observation suggested a review of 100 diagnostic roentgenograms of the knee joint. These were picked at random, except for the rejection of those with destructive lesions or joint fractures. Only those in or near extension were measured, and in all the smallest space interval was used. Where there was overlapping of bone and no space, the overlap was measured and recorded as a minus quantity. The anteroposterior view was used. The average joint space on the medial side was 0.53 millimeters and on the lateral side, 3.48 millimeters; the average difference in the joint spaces was 2.95 millimeters. The greatest joint space on the medial side was 6.8 millimeters, and on the lateral side 9.2 millimeters. The greatest difference between the medial and lateral spaces was 7.2 millimeters; the smallest difference was 0.4 millimeters. On the face of this evidence it seemed that there should be abnormal lateral motion present when the lateral meniscus was removed, but on both preserved and fresh joints this was not borne out (Table I).

The menisci cushion hyperextension and hyperflexion. (The menisci do not cushion a blow from above or below because condylar articular contact between the tibia and the femur is always present.) The menisci fill an otherwise dead space between the periphery of the condyles of the tibia and the femur, and keep capsule and synovia from becoming pinched between the femoral and tibial condyles. (One complete discoid cartilage was found in this series of joints.)

The ligament of Wrisberg, when present, tends to control the lateral meniscus, pulling it backward in flexion and preventing it from sliding too far forward in hyperextension.

The alar folds, ligament mucosa, and transverse ligament seem to defy assignment to a concrete function. When present the transverse ligament is taut in hyperextension, tending to prevent excessive separation of the anterior aspect of the menisci.

DISCUSSION

The following statements are generally accepted without controversy: Both collateral ligaments are taut in complete extension. The cruciate ligaments by twisting on themselves prevent abnormal medial rotation of the tibia on the femur. In the beginning of flexion the femoral condyles roll on the tibial condyles (certainly the lateral femoral condyle rolls on the lateral tibial condyle, but whether the medial femoral condyle rolls at all is under investigation), and, after a certain degree of

flexion, the femoral condyles glide at one point on the tibial condyles. There is a small amount of lateral motion present in the normal knee joint. A certain amount of rotation is normally present in the flexed

TABLE I

CONTROL BY THE LIGAMENTS OF LATERAL AND ROTARY MOTION IN FRESH INTACT AND PRESERVED KNEE JOINTS *

Ligaments Cut	Fresh Intact Joints							Stripped Preserved Joints						
	Joint No.	Degree of Lateral Motion			Degree of Rotation			Joint No.	Degree of Lateral Motion			Degree of Rotation		
		Hyperextension	90-Degree Flexion	Full Flexion	Hyperextension	90-Degree Flexion	Full Flexion		Hyperextension	90-Degree Flexion	Full Flexion	Hyperextension	90-Degree Flexion	Full Flexion
None	1	2	4	3	2	6	6							
Tibial Collateral	1	2	5	5	2	12	12	9	2	6	5	2	29	21
Both Collaterals	1	5	5	5	2	20	15	10	1	2	1	180?	180?	180?
Both Collaterals and Anterior Cruciate	1	10	10	10	20	25	20							
All Ligaments	1	10	18	13	25	35	20							
None	2	2	5	3	5	7	9							
Fibular Collateral	2	3	6	4	5	9	9	11	3	1	1	4	10	10
Fibular Collateral and Anterior Cruciate	2	7	11	8	11	15	11	12	13	13	9	12	50	45
Both Collaterals and Anterior Cruciate	2	11	17	9	13	23	9							
All Ligaments	2	11	18	10	13	25	10							
None	3	5	6	8	2	16	18							
Posterior Cruciate	3	4	9	9	6	14	12	13	2	6	9	2	25	38
Both Cruciate Ligaments	3	4	9	8	7	17	14	14	2	10	15	2	44	47
Both Cruciates and Fibular Collateral	3	4	9	7	6	18	18							
All Ligaments	3	5	21	14	6	22	14							
None	4	5	9	5	10	18	7							
Anterior Cruciate	4	6	9	8	10	17	9	15	4	5	11	3	13	13
Anterior Cruciate and Tibial Collateral	4	7	15	9	10	27	7	16	Defies Measuring					
Both Cruciates and Tibial Collateral	4	6	31	19	10	31	10							
All Ligaments	4	6	32	27	10	33	19							
None	5	2	5	3	2	15	11	17	1	3	2	1	15	2
None—Lateral Meniscus Removed	5	3	6	6	2	18	15	18	1	6	4	1	10	7
None—Both Menisci Removed	5	3	5	6	4	20	19	19	2	6	6	2	19	13
Both Menisci and Tibial Collateral	5	3	10	7	6	24	19							
Both Menisci and Both Collaterals	5	3	13	10	7	30	26							
Menisci, Both Collaterals, and Anterior Cruciate	5	7	16	9	13	29	24							
Menisci, Both Collaterals and Cruciates	5	6	17	14	12	27	24							
None	6	2	8	7	4	24	21							
None—Medial Meniscus Removed	6	2	9	8	4	21	21	20	1	1	1	1	4	2
Medial Meniscus, Posterior Cruciate, and Tibial Collateral	6	9	28	27	6	48	34	21	14	55	57	30	107	90
Medial Meniscus, Posterior Cruciate, and Both Collaterals	6	11	32	32	10	49	36							
None	7	2	4	3	2	10	4							
Tibial Collateral	7	2	7	4	2	10	5							
Both Collaterals	7	2	6	3	2	10	5							
Both Collaterals and Anterior Cruciate	7	2	9	5	4	12	6							
All Ligaments	7	2	12	12	4	25	15							
None	8	2	4	6	5	11	15							
Fibular Collateral and Posterior Cruciate	8	4	10	13	6	24	19	22	4	16	19	24	39	34
All Ligaments	8	6	29	25	11	42	33							
None—Medial Meniscus Displaced								23	2	6	5	1	13	20

* Ligaments were cut through a small incision in the joint and incision sutured in the intact fresh joint.

position. There is lateral rotation of the femur on the tibia in the first few degrees of flexion. The posterior aspect of the capsule and the oblique popliteal ligament aid in preventing hyperextension. The fibular collateral ligament is relaxed in flexion.

All agree that muscular, tendinous, and fascial structures about the knee make up one of its important stabilizers and add great strength to the joint.

It is generally accepted that the tibial collateral ligament is intimately attached to the medial meniscus by fibrous tissue (Campbell [5], Henderson [22], Saunders [40], Horwitz [25], Smith [42], Valls [45], etc.). From the study of the present series of joints, it seems evident that there is no strong fibrous tissue connecting these two structures. To verify this, further investigation is being carried on.

Motion of the menisci gives good evidence that the medial femoral condyle acts more nearly as the axis of rotation of the knee joint. The backward or forward motion of the menisci is controlled by the movement of the femoral condyles. In moving from extension to flexion the lateral meniscus moves backward a considerable distance which indicates the rolling backward of the lateral femoral condyle and corresponds to the lateral rotation of the femur. The medial meniscus moves backward only very slightly.

It is evident from its attachments and position that the anterior cruciate ligament prevents forward gliding of the tibia on the femur, and the same can be said about backward gliding being prevented by the posterior cruciate ligament. However, in hyperextension both collateral ligaments are tight and, therefore, by forcing the tibia and femur tightly together will reduce such motion to a minimum. In determining the effect of the tibial collateral ligament on this function, its attachment must be carefully considered. If it were firmly attached to the whole adjacent portion of the tibia, it would prevent forward and backward motion of the tibia on the medial side, but it is not so attached. Its posterior attachment, however, does limit posterior gliding on the medial side while in complete extension, though its posterior portion is relaxed in flexion. The fibular collateral ligament cannot possibly exert any effect in flexion because it is relaxed. Clinically, anterior and posterior motion can always be demonstrated under the relaxation of anaesthesia if either the anterior or posterior cruciate ligament is ruptured (Pringle [37], Milch [34], Cubbins, Callahan, and Scuderi [12]).

That some portion of the tibial collateral ligament is taut in all phases of extension and flexion is evident from the fact that abnormal rotation of the joint is prominent when this ligament is cut.

It is evident from Table I and the work already discussed that both collateral ligaments, both cruciate ligaments, and the capsule are important in maintaining the lateral stability of the joint. Clinically, collateral ligament injuries have associated cruciate ligament injuries and there may or may not be menisci injuries (Cubbins, Callahan, and Scuderi [13], Camp-

bell [6], Conwell [10], Bosworth and Bosworth [3], Valls [45], Conwell and Alldredge [9]). Considering the small part the menisci play in lateral stability, one has only to consider the well-established fact that a normally functioning knee usually results when one or both menisci are removed at operation. This is borne out by Table I.

The most relaxed position of the joint capsule is from 15 to 30 degrees of flexion because all the joints assumed this position when distended by the injection of plaster. In order to have the joint in the extended position, it had to be held so until the plaster hardened.

In discussing the advisability of repairing the anterior cruciate ligament only or the tibial collateral ligament only when both are ruptured, it is probably safe to state that both should be repaired. In the knee joint there is a very close interrelationship among the functions of the collateral and cruciate ligaments, and the capsule. It is hardly possible to give one or more separate and definite functions to any one ligament. When the capsule is incised and sutured, it is intentionally or unintentionally tightened. If either the tibial collateral ligament or the anterior cruciate ligament is repaired, when both are ruptured, then there is restored to normal all but one of the five important stabilizing structures of the knee joint (disregarding muscular support). Therefore, the repair of either the tibial collateral or the anterior cruciate ligament gives a satisfactorily functioning knee joint. The close interrelationship of the ligaments is the important factor in restoring stability, and not the greater importance of one ligament over the other.

CONCLUSIONS

The integrity of the knee joint depends upon the muscles and tendons about the knee, the articular capsule, the intrinsic ligaments of the joint, and the bone architecture of the tibia and femur.

Lateral motion of the knee joint in extension is controlled by the capsule, collateral ligaments, and cruciate ligaments; in flexion, by the same structures minus the fibular collateral ligament.

Rotary motion of the knee joint in extension is controlled by capsule, collateral ligaments, and cruciate ligaments; in flexion, by the same structures minus the fibular collateral ligament.

Forward gliding of the tibia on the femur is controlled by the anterior cruciate ligament.

Backward gliding of the tibia on the femur is controlled by the posterior cruciate ligament.

Lateral gliding of the tibia on the femur is controlled by the tibial intercondyloid eminence and the femoral condyles with the aid of all the ligaments.

Hyperextension is controlled by both collateral ligaments, both cruciate ligaments, both menisci, the posterior aspect of the articular capsule, the oblique popliteal ligament, and the architecture of the femoral condyles.

Hyperflexion is controlled by both cruciate ligaments, both menisci, the femoral attachment of the posterior aspect of the capsule, the femoral

attachment of both heads of the gastrocnemius muscle, and the bone structure of the condyles of the femur and the tibia.

The menisci cushion hyperextension and hyperflexion.

The tibial collateral ligament is closely related to the medial meniscus, but there is no strong fibrous-tissue attachment between them.

The tibial collateral ligament glides forward and backward in extension and flexion.

The drawings from which were made Figures 1 to 12 are the work of Ruth Bialek.

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THE CONSERVATIVE COMPENSATION-DEROTATION TREATMENT OF SCOLIOSIS *

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The law that adequate treatment of deformity implies complete restoration of form as well as of function cannot be applied to the case of structural scoliosis without qualification.

In the first place, one cannot speak of restoration of form in the strict anatomical sense except in a few cases. In the second place, if recovery of function means complete automatic muscle-controlled stability and mobility, it is a requirement which can be met fully only in rare instances. Consequently, according to the standard of treatment in other deformities, the treatment of scoliosis is a compromise.

We believe that this compromise is acceptable for three reasons.

1. The important factor in the deformity is not the curve itself, but rather the loss of posture which it involves—the lack of alignment between the head, shoulders, and pelvis—so even if it is not possible to restore the anatomical form of the column, it is possible in a majority of cases, to approach a normal posture. We call this the realignment of the spine by compensation.

2. When this passive realignment is once obtained, the musculature can in a great many cases, be adequately developed to maintain actively the posture so regained, even though the mobility of the spine has been greatly reduced by the scoliosis.

3. In the absence of adequate musculature, the entire mobility of the spine can be sacrificed by fusion, and the posture thus maintained passively.

In any event, restoration of alignment or posture is a necessary prerequisite. The question then is, whether the two prerequisites of successful conservative treatment—the degree of compensation necessary to restore posture or general trunk alignment, and the degree of muscle function required to maintain it actively—are available.

It is practically impossible to answer this question at the outset except in the negative sense. For instance, we may be certain that in a severe high thoracic or thoracocervical scoliosis satisfactory realignment cannot be obtained, or that, in a case of paralytic scoliosis, adequate muscle development is out of the question. In the great majority of cases, however, realignment and maintenance of posture represent two

* Read before the Meeting of the American Orthopaedic Association, Kansas City, Missouri, May 7, 1940.

FIG. 1-A

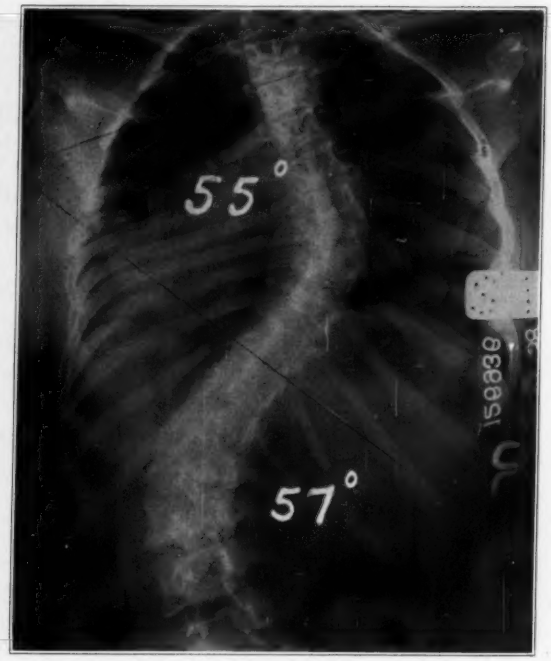

FIG. 1-B

Photograph (Fig. 1-A) and roentgenogram (Fig. 1-B) show habitual scoliosis with a spontaneous compensation of a thoracic curve of 55 degrees by a lumbar curve of 57 degrees. Compensation is holding after four years.

individual variables which only long study and observation of the specific case can evaluate.

TYPES OF CASES

In practice we meet five types of cases as follows:

1. Those which realign or compensate themselves spontaneously and, with adequate muscle power at their disposal, maintain such correction during the period of rapid growth and after adolescence (Figs. 1-A and 1-B). This is a small group of 30 per cent.

2. Those in which adequate compensation can be accomplished by conservative means, without destroying the stability of the spine, and in which, also, adequate muscle tone to maintain such correction can be developed by conservative treatment. Here belong the majority of slight and moderate habitual and rachitic cases (Figs. 2-A, 2-B, 3-A, and 3-B).

3. Those in which adequate compensation can be maintained, and where adequate muscle power can be developed, but where, because of marked adaptive or congenital osseous changes, and in spite of good musculature, compensation is likely to break down again. The more severe habitual cases, still progressing, and the congenital cases, especially those with an oblique fifth lumbar vertebra, belong to this group. The spines of these patients probably should be fused.

FIG. 2-A

FIG. 2-B

Photograph (Fig. 2-A) and roentgenogram (Fig. 2-B) show habitual scoliosis. Compensation of a thoracic curve of 65 degrees by a lumbar curve of 70 degrees was obtained by conservative treatment. Compensation is holding after four years.

FIG. 3-A

FIG. 3-B

Photograph (Fig. 3-A) and roentgenogram (Fig. 3-B) show rachitic scoliosis. Compensation of a thoracic curve of 40 degrees by a lumbar curve of 38 degrees was obtained by conservative treatment. Compensation is holding after three years.

4. Those in which alignment is possible, but no adequate muscle tone can be obtained. This includes most paralytic cases. The spines in these cases also should probably be fused.

5. Those which cannot be adequately realigned because of severe

FIG. 4

Roentgenogram showing congenital scoliosis. Observation time two years.

FIG. 5

Roentgenogram showing habitual scoliosis. Observation time four years.

FIG. 6

Roentgenogram showing paralytic scoliosis. Observation time five years.

FIG. 7

Roentgenogram showing rachitic scoliosis. Observation time six years.

Figs. 4–7 illustrate scolioses which were not compensable.

structural deformity. These include the most severe congenital cases (Fig. 4); the severe and inveterate habitual type (Fig. 5); the most severe paralytic type (Fig. 6); and those with a severe cervicothoracic rachitic curve. If the condition is still progressing, the spine should be fused; if it

FIG. 8

Roentgenogram showing a thoracic curve compensated by a lumbar curve.

FIG. 9

Roentgenogram showing a high thoracic curve compensated by a cervicothoracic curve.

FIG. 10

Roentgenogram showing a thoracolumbar curve compensated by a lumbosacral curve.

FIG. 11

Roentgenogram showing a long thoracic curve compensated by a cervicothoracic and a lumbar curve.

is already set, it should be left alone or treated by support. In neither instance is the treatment satisfactory.

ALIGNMENT BY COMPENSATION-DEROTATION

Adequate Alignment

In an adequate alignment by compensation-derotation a perpendicular line, drawn from the middle of the bimastoid line and passing through the mid-point of the shoulder line, should strike the gluteal cleft. The compensation, by the development of one or more counter-curves of the opposite order, abolishes obliquity of the shoulder line, elevation of the shoulder, and protrusion of the pelvis on the concave side. A maximum of four curves is possible: cervical or cervicothoracic, thoracic, thoracolumbar or lumbar, and lumbosacral.

FIG. 12

Roentgenogram showing a lumbar curve compensated by a lumbosacral curve and an oblique fifth lumbar vertebra.

A mid-thoracic primary curve is compensated by a lumbar curve (Fig. 8);

A high thoracic curve, by a cervicothoracic curve (Fig. 9);

A thoracolumbar curve, by a lumbosacral curve (Fig. 10);

A long thoracic curve, by a cervicothoracic and a lumbar curve (Fig. 11);

A lumbar curve, by a lumbosacral curve with oblique fifth lumbar vertebra (Fig. 12).

Results of Compensation-Derotation

The nature of the scoliosis determines the limits of correction. Although in all scolioses lateral deviation is combined with rotation on the convex side, the relative degree of the two deforming elements varies.

The inclinatory or contracture type, such as paralytic scoliosis, is much more easily compensated than the structural or collapse type. In this latter type, the translatory shift of the vertebrae indicates that they are not anchored in the costal cage, as in rachitic scoliosis. The lateral deviation, as well as the rotary element of the deformity, represents structural changes. Consequently, treatment of the inclinatory or contractural-type of scoliosis—early habitual or paralytic—will result in much better correction than will treatment of the collapse or structural type.

Finally, it must be realized that when the spine rotates, the thoracic cage does not follow it as one mechanical unit. It is more correct to say that the spine moves into the convex side of the thorax in both lateral

deviation and rotation. As the spinal column rotates, the thoracic cage is, more and more, left behind the much more rapidly rotating column, so that it actually remains on the concave side of the spinal curve. The usual attempt to correct the rib deformity by concave-side rotation is, therefore, inherently wrong, and can have no other effect than to accentuate the already existing disproportion between the spine and the thorax.

If compensation is obtained before the period of rapid growth, there is a tendency, during this period, for the curves to settle with an increase in angular values, though the compensation is not lost.

Method

If the sections of the spine beyond the curve are sufficiently pliable, the immediate effect of bending the trunk to the convex side is always the production of counter curves above and below the primary one. It is only secondarily that the primary curve is shortened and flattened according to the degree of its rigidity. Hence compensation becomes doubtful in cases of obliquity of the fifth lumbar vertebra; moreover, the compensation of the cervicothoracic or low lumbar curves is difficult. If a thoracic primary curve, with the tenth thoracic the transitional

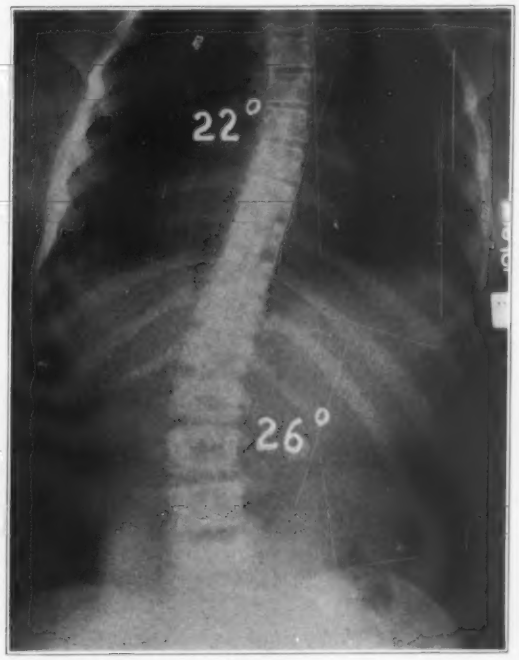

FIG. 13-A FIG. 13-B

Photograph (Fig. 13-A) and roentgenogram (Fig. 13-B) illustrating adequate treatment of a habitual scoliosis by complete lumbar compensation in a patient with a thoracic primary curve, horizontal pelvis, and horizontal fifth lumbar vertebra.

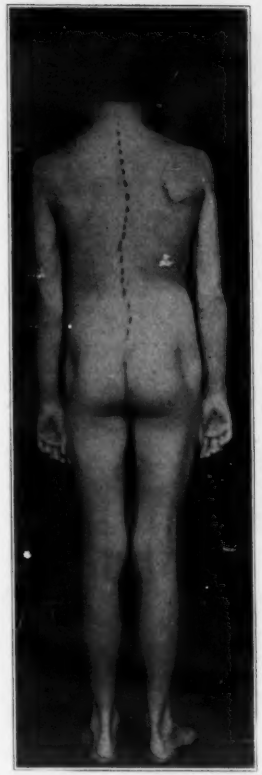

FIG. 14-A

FIG. 14-B

Photograph (Fig. 14-A) and roentgenogram (Fig. 14-B) illustrating adequate treatment of a habitual scoliosis by complete lumbar compensation in a patient with a primary thoracic curve, horizontal pelvis, and oblique fifth lumbar vertebra.

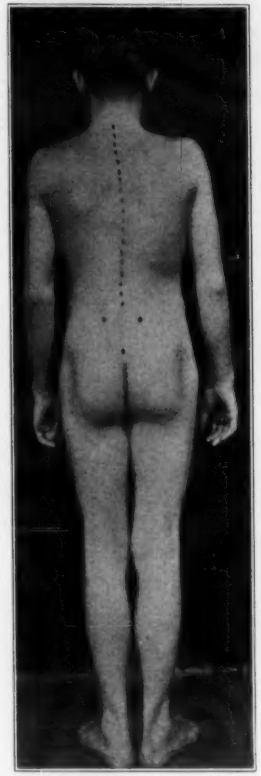

FIG. 15-A

FIG. 15-B

Photograph (Fig. 15-A) and roentgenogram (Fig. 15-B) illustrating adequate treatment of a congenital scoliosis with a short moderate dorsal curve. The spine above and below the curve was straight, and the patient had passed the period of rapid growth.

vertebra, is not too long, both upper and lower counter curves may be adequately developed. In a thoracic primary curve, with the twelfth thoracic the transitional vertebra, the lumbar counter curve may be developed and complete compensation obtained. In a thoracolumbar primary curve, with the first lumbar the transitional vertebra, a lower lumbar curve may still be possible, except when there is an oblique fifth lumbar vertebra. A lumbar scoliosis with an oblique fifth lumbar vertebra progresses, and later may develop a secondary thoracic counter curve, but the maintenance of compensation without fusion is doubtful.

The compensation-derotation treatment consists in:

Equilibration of the Pelvis

The pelvis must be horizontal with its rotation corrected. Difference in the length of the extremities must be equalized (Figs. 13-A and 13-B).

Elimination of Weight-Stress

Pending the development of active muscle balance and the mobilization of the spine to develop adequate counter curves, the spine must be protected. This is done in the

FIG. 16-A FIG. 16-B

Photograph (Fig. 16-A) and roentgenogram (Fig. 16-B) illustrating adequate treatment of a congenital or rachitic scoliosis in a patient with a horizontal pelvis and horizontal fifth lumbar vertebra.

beginning by recumbency and traction, and later by mechanically adequate support. Mechanical adequacy of support implies: (1) a neck extension piece to control the spine above the eighth thoracic vertebra, and (2) a leg extension piece to secure the trunk against the pelvis.

FIG. 17

Roentgenogram showing a severe paralytic scoliosis which was compensated, but in which the compensation failed to hold.

FIG. 18

Roentgenogram showing a rigid lumbar spine which could not be compensated.

FIG. 19

Roentgenogram showing scoliosis in a patient with an oblique pelvis. Conservative treatment was inadequate.

FIG. 20

Roentgenogram showing a congenital high thoracic scoliosis which was not compensable.

Mobilization of the Spine

Mobilization of the spinal sections adjacent to the primary curve by side-bending and derotation is undertaken for the purpose of developing alignment by compensatory curves. The passive mobilization is effected by side-bending and derotation manoeuvres already described on previous occasions.[1] Forcible compensation by a Risser cast commits one to subsequent fusion and is, therefore, to be reserved for prospective operative cases. It is certain that the development of counter curves and the shortening of the primary curve is better obtained by the corrective cast, but a spine so treated does not hold this correction of its own accord and, therefore, must be fused.

FIG. 21

Roentgenogram showing congenital scoliosis in a patient with an oblique pelvis and an oblique fifth lumbar vertebra for which conservative treatment was inadequate.

Development of Muscle Tone

Systematic development of muscle tone and improvement of the mechanical efficiency of the musculature by symmetrical and asymmetrical exercises are aimed at the active maintenance of correction. These exercises are especially designed to develop the long back and abdominal muscles, and to provide freedom and strength in the rotary movements of the shoulder girdle and pelvis. Compensation curves are developed automatically by the rotation of the shoulder girdle and pelvis in the direction opposite to the primary curve. The mechanical adequacy of these curves depends upon the nature, size, and degree of the primary curve, and upon the amount of pliability of the other sections of the spine from which the counter curves are formed. Maintenance of correction ultimately depends upon the active development of the tone of the back and shoulder muscles.

It is, therefore, necessary that muscle development keep step with the mobilizing methods. A brace is applied while the musculature is being developed to a state of mechanical sufficiency. The effect of this brace is not curative, but preventive. It is to safeguard, to enforce active correction and active maintenance of posture, and to prevent the progression of the curve by collapse.

Secondary decompensation may develop from muscular insufficiency, in one of two ways: Either, the primary curve may extend upward into the cervicothoracic section, with an overhang of the head on the concave

side and a secondary readjustment of the head over the pelvis by shifting the trunk toward the convex side; or it may extend downward into the lumbar compensatory curve, with a total shift of the trunk toward the convex side:

During the ambulatory period the brace provides against the former event through its neck piece, and against the latter through its thigh piece.

CRITERIA OF MUSCLE SUFFICIENCY

1. Standing and recumbent lengths of the thorax are the same.
2. Distensibility of the spine is diminished.
3. Posture is maintained actively, permanently, and without effort.
4. Normal sense of thoracic equilibrium is restored.

INDICATIONS AND CONTRA-INDICATIONS

The compensation-derotation treatment is adequate when the following conditions are present:

1. Complete lumbar compensation of a thoracic primary curve with horizontal pelvis and horizontal fifth lumbar vertebra, as in a habitual scoliosis with a moderate curve (Figs. 13-A and 13-B).

2. Complete lumbar compensation of the thoracic primary curve with horizontal pelvis, but oblique fifth lumbar, as in a non-paralytic scoliosis, with a straight upper thoracic spine and a moderate curve (Figs. 14-A and 14-B).

3. A short and moderate thoracic curve with a straight upper and straight lumbar spine, as in a congenital or habitual scoliosis in a patient who has passed the period of rapid growth (Figs. 15-A and 15-B).

4. A primary lumbar curve, with a horizontal pelvis and a horizontal fifth lumbar, as in a rachitic or congenital scoliosis (Figs. 16-A and 16-B).

The compensation-derotation treatment is inadequate in the following cases:

1. All paralytic cases, with possibly a few exceptions of the mildest types (Fig. 17).

2. Severe cases of all ages and types, which, because of a rigid lumbar spine, remain uncompensated (Fig. 18).

3. All scolioses with oblique pelvis, except those in patients close to the completion of growth (Fig. 19).

4. All high thoracic or cervicothoracic curves, not completely compensable. There are, however, some congenital high thoracic and cervicothoracic cases with congenital fusion which hold after conservative treatment (Fig. 20).

5. Congenital scoliosis with oblique pelvis and oblique fifth lumbar (Fig. 21).

RESULTS OF TREATMENT

Eighty per cent. of our patients were treated conservatively and only 20 per cent. were operated upon.

Of these, one hundred cases treated conservatively by the compensation-derotation method, were selected on the basis of completeness of record and time of observation. All had five years or more of post-treatment observation. The types of these scolioses were distributed as follows:

Habitual	69
Paralytic	14
Rachitic	7
Congenital	10
	100

Sixty-four of the spines were mobile and thirty-six rigid at time of the examination. Spontaneous compensation had occurred at that time in thirty cases, of which twenty-four were habitual, three congenital, two rachitic, and one paralytic. Complete compensation was obtained by treatment in fifty cases, incomplete or no compensation in twenty cases.

As a result of this type of treatment the correction held in eighty cases and failed in twenty.

Nine of the failures were paralytic cases, which indicates an error in selection. It should be noted that of the twenty cases which could not be adequately compensated, only one held; the others failed.

All cases of spontaneous compensation held in the presence of good musculature. No attempt was made to correct the primary curve except in five of these cases, and they finally lost their compensation and failed because of inadequate musculature; the rest were kept under careful observation, proper support, and development of the musculature, and remained compensated.

Paralytic and severe structural non-paralytic scolioses did not respond to conservative treatment alone and in these patients, who are not considered in this series, the spine had to be fused. An increase in the primary curve took place under conservative treatment in individuals before or early in the period of rapid growth, but not in older patients. However, this did not mean a break in compensation or loss of posture.

A later series of twenty-one cases, treated conservatively by the combined derotation-compensation method with a follow-up of two years or more, gave the following results:

Four, or 19 per cent. of the patients were compensated on admission, and were treated by support and muscle development only; all of them maintained the correction.

Seventeen, or 81 per cent. were not compensated at admission, and were treated by manipulative correction, derotation, muscle development, and support. The average period of time necessary to obtain complete

compensation was eight months. Of these seventeen, only one patient with a congenital scoliosis and a hemisacralization of the fifth lumbar failed to respond.

In this series twenty cases, or 95 per cent., held their correction, and one, or 5 per cent., failed to do so.

There were no paralytic cases in this series and only two congenital. The improvement of results over the former series (95 per cent. versus 80 per cent.) is due to the better selection of cases.

CONCLUSIONS

1. Compensation of the scoliosis is a necessary prerequisite for maintenance of correction and posture.

2. The combined compensation-derotation method is adequate to obtain compensation in suitable cases and leads to definite maintenance of posture.

3. The rotary deformity of the thoracic spine cannot be corrected at present. Attempts to correct the thoracic deformity by rotation to the concave side are preposterous. The thorax is already rotated to the concave side in relation to the spinal column, and such attempts only make the situation worse.

4. Derotation is directed toward the lumbar and cervicothoracic section of the spine, and, by limbering up these sections, aids in the development of adequate counter curves.

5. If the compensation can be accomplished without forcible cast correction, and provided muscle development is adequate, the spine need not be fused. However, if the compensation must be forced by a cast, fusion will become necessary to hold the correction obtained.

6. Failure must be expected, with or without fusion, when compensation is lost or not obtained. Only a few cases at the end of the growth period hold the correction when decompensated.

7. Failure must also be expected in the absence of adequate muscle development, unless fusion is performed.

8. Compensation-derotation plus adequate muscle development promises success in the great majority of all non-paralytic cases.

9. Adequate compensation-derotation plus fusion in the presence of inadequate musculature, likewise, holds out promise of success in all paralytic and many congenital cases.

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TREATMENT OF GAS GANGRENE EXPERIMENTALLY PRODUCED

BY GUY A. CALDWELL, M.D., NEW ORLEANS, LOUISIANA

Since 1892 when Welch [11] first described the bacillus later given his name, persistent efforts have been directed toward controlling the infection by medicinal agents, antitoxins, roentgen-ray therapy, and surgical measures. Recent experimental work on mice indicates that *p*-aminobenzenesulfonamide (sulfanilamide) has definite bacteriostatic action against Welch's bacillus. That patients with gas gangrene have shown improvement and even recovery following the administration of sulfanilamide is clinical evidence supporting such studies [1]. Jensen and his coworkers [5] were able to reduce considerably the incidence of gas gangrene associated with compound fractures when this drug was implanted in the débrided wound. Because few pyogenic infections develop in compound wounds débrided and treated with sulfanilamide, it was believed safe to close most of them without drainage. Closure of wounds communicating with fractures and contaminated by organisms producing gas gangrene was previously considered dangerous [2, 3]. It, therefore, has become important to determine accurately whether débrided wounds implanted with sulfanilamide may be closed without fear of further progress of the infection.

Bliss and Long [8] in a report of their experimental work state, "Recently we have noted that sulfanilamide has a curative effect in mice infected with Clostridium welchii. Studies made on the peritoneal exudates of treated and untreated mice have been of great interest. . . . The inoculum was prepared. . . . Then 0.5 c. c. of this suspension was inoculated by the intraperitoneal route into test mice. . . . At six hours and fifteen minutes after infection all three control mice were dead of toxemia, while the treated mice were well on the way to recovery. . . . The results of these and other similar experiments with Clostridium welchii seem to indicate that as far as this particular organism is concerned sulfanilamide acts primarily by reducing the rate of multiplication of the organisms in the peritoneal cavity of the infected animals. In other words, the chemical has a bacteriostatic action in vivo as well as in vitro."

These experiments, indicating that sulfanilamide acts primarily by reducing the rate of multiplication of the organisms in the peritoneal cavities of infected animals, suggested that *when the clostridia are propagating more rapidly*, as they do in devitalized muscles [10], *the effect of the drug might not be so curative.* Kendrick [7] was the first to report experiments in which gas gangrene was induced primarily in the muscles and treated with sulfanilamide. Since most clinical cases occur in the muscles surrounding compound fractures, accurate evaluation of the efficacy of the drug can be made only by experimentally producing a compound fracture, using Welch's bacillus, and then treating the animal with sulfanilamide.

Because several clinical reports [4,6] in recent years have shown that roentgen-ray therapy arrests the progress of gas gangrene and no satisfactory experimental work has been carried out to substantiate this theory, it was decided to induce gas gangrene in the muscles of guinea pigs and subject them to irradiation.

The Welch's bacillus is an obligatory anaerobe which propagates slowly with little tendency to invade tissue in the presence of adequate amounts of oxygen. Many oxidizing agents have, therefore, been tried, but found relatively inefficacious when the infection occurs in deep wounds of the muscles. Recently, Meleney and Johnson[9] have found, however, that a paste made from zinc peroxide emits oxygen slowly over a period of twenty-four hours. They were able to destroy various anaerobes by placing this paste in crater-like wounds containing these organisms. No experiments have been reported in which zinc peroxide has been implanted in wounded muscles infected with Welch's bacillus. Experiments were, therefore, planned to determine whether zinc peroxide would prevent the development of gas gangrene in compound fractures.

PLAN OF THE EXPERIMENTS

Guinea pigs were selected for the experiments because of their susceptibility and because their bones are large enough to permit drilling several holes in the cortices of their femora. Since it is not practical to splint and dress the fractured bones of guinea pigs, the marrow cavity was exposed to infection by drilling multiple holes through the outer cortex, thus producing the counterpart of a compound fracture which did not necessitate splinting. A transplant of the strain of the Welch's bacillus employed by Bliss and Long[8] in their experimental work on mice was obtained. Its morphological and cultural characteristics were verified and further transplants then used throughout the experiments.

Each guinea pig was anaesthetized with ether and a short incision was made on the outer side of the right thigh. The fascia and muscles were split and retracted, and drill holes were made in the cortex of the femur. The muscle fibers were then cut transversely in several places and crushed with a hemostat. Amounts of a twenty-four-hour broth culture of the Welch's bacillus, varying from 0.15 to 0.3 cubic centimeters were dropped into the wound (not injected into the body of the muscles). The incision was then sutured with continuous silk, and, after intervals of from one to six hours, various treatments and surgical measures were instituted.

Implantation of Sulfanilamide Crystals

Nineteen guinea pigs were prepared as described above. At intervals of from one to six hours after the inoculations, débridements were done, but the wounds were not irrigated. Fifteen to 30 milligrams of sulfanilamide crystals were then sprinkled over the surfaces of bone and muscles, and the wounds were sutured.

Results. Of these nineteen animals, fifteen died after six to forty-eight hours and the other four lived. Eight controls, inoculated only, died after fourteen to eighty-six hours. Four controls to determine the effect of operative trauma, anaesthetics, and toxicity of the drug, lived.

Intraperitoneal Injections of Sulfanilamide

A second series of experiments was undertaken to determine whether intraperitoneal injections of sulfanilamide would prevent the development of gas gangrene when the infected wounds were débrided, irrigated with saline solution, and left open. Two hours after the inoculation of the wound, a débridement of the skin, fascia, and muscles was done, followed by irrigation of the wound with saline solution. Immediately after this procedure, 50 milligrams of sulfanilamide were given intraperitoneally and repeated every six hours until the animal either expired or had lived forty-eight hours.

Results. Of nine animals thus treated, seven lived and two died after twelve hours. Control experiments on ten animals carried out with slight variations resulted in the death of eight after eighteen to ninety-six hours, and the survival of only two.

Implantation of Zinc Peroxide

Wounds were infected with Welch's bacillus as in the preceding experiments. After two hours these were débrided, irrigated with saline, and a thin paste made of zinc peroxide after the method of Meleney [9], was poured into the wound and retained by suturing the skin. After forty-eight hours, the wounds were opened, remnants of the paste were removed by irrigations with saline, and the wounds were left open.

Results. Four of the five animals lived, the other died; two animals, inoculated only, died in thirty-six hours. The four animals that survived developed moderate swelling of the thighs for twenty-four hours, did not appear ill, and never had the clinical evidences of gas gangrene. The animal that died had gas gangrene, but upon opening the wound it was found that the paste of zinc peroxide remained waxy, firm, and brownish in color, whereas in all the other animals it had changed into hard, white crystals of zinc oxide.

Roentgen-Ray Therapy

To determine the effect of roentgen rays upon the development of gas gangrene, two series of experiments were performed. The first group of animals was so traumatized and infected as to produce a fulminating type of infection ending in death of the controls at twelve to fourteen hours. The second group with less trauma and smaller numbers of organisms had less severe infections resulting in death of the controls after forty-eight to seventy-two hours. To estimate accurately the value of roentgen rays in combatting gas-gangrene infection, this group of animals received no treatment except roentgen therapy. The first

group was given 100 to 200 roentgen units one to three hours after the inoculation.

Results. Of ten animals thus treated, three lived and seven died after eight to eighteen hours. Four controls, similarly inoculated but not treated, died after twelve to seventy-two hours. All three of the surviving animals had the clinical manifestations of gas gangrene during the first forty-eight hours; the process then became localized, the gas and oedema disappeared, and there appeared extensive areas of dry necrosis of the skin followed by deep sloughing into the muscular layers.

SUMMARY

An effort has been made to produce experimentally, in guinea pigs, the counterpart of a compound fracture infected with a lethal number of Welch's bacilli, and to treat these in some of the various ways suggested by clinical and laboratory observations.

Débridement of the wounds followed by implantation of 15 to 30 milligrams of sulfanilamide crystals and closure resulted in the survival of only four of nineteen animals.

Débridement and irrigation of similar wounds left open, and followed by the administration of 50 milligrams of sulfanilamide intraperitoneally every six hours, resulted in the survival of seven of nine animals.

Débridement and irrigation of such wounds followed by implantation of zinc peroxide paste and suture of the wounds resulted in the survival of four of five animals.

Wounds similarly produced and sutured and treated with roentgen rays in varying dosage at different intervals were followed by death in seven of ten animals.

CONCLUSIONS

As far as can be determined by experiments in which a crude counterpart of a compound fracture infected with Welch's bacillus has been produced in the thighs of guinea pigs, the following observations are correct:

1. Sulfanilamide crystals implanted in such infected wounds after débridement seldom control or prevent the development of gas gangrene.

2. Administration of large doses of sulfanilamide by intraperitoneal injection after the wound has been débrided, irrigated, and left open precludes the development of gas gangrene in a high percentage of cases.

3. Implantation of zinc peroxide paste in débrided wounds prevents the development of gas gangrene in most instances.

4. Roentgen-ray treatment has no effect upon the progress of a fulminating type of gas gangrene, but does bring about some localization of the process when given one to two hours after inoculation, and when the animals survive forty-eight hours and longer.

5. The bacteriostatic effect of sulfanilamide upon Welch's bacillus injected into the abdomen is not duplicated when the same organisms are planted in traumatized muscular tissue.

6. Further experiments should be carried out to confirm these conclusions, and others to ascertain whether combinations of zinc peroxide paste in the wound and sulfanilamide given orally or intraperitoneally may not be more effective than either of them alone.

Experiments were carried out in the laboratories of the Touro Infirmary with the advice and valued assistance of the late John A. Lanford, M.D., Assistant Professor of Pathology and Bacteriology, and Meyer D. Teitelbaum, M.D., Instructor in Radiology, Tulane University of Louisiana, School of Medicine. Their sincere interest and help are gladly acknowledged and greatly appreciated.

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SURGICAL APPROACH TO THE PROXIMAL END OF THE RADIUS AND ITS USE IN FRACTURES OF THE HEAD AND NECK OF THE RADIUS

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The approach to the radial head and neck is not considered very difficult, because the head is rather superficially located and may appear easily accessible. However, in spite of its apparent ease and accessibility, there are important anatomical structures which change position with pronation and supination of the forearm. The change in the relative position of these structures with pronation and supination is very important and must be known to avoid serious injury to the branches of the radial nerve.

A preliminary anatomical study was made of this region with the intention of establishing: first, the relationship of the branches of the radial nerve to the lateral epicondylic ridge of the humerus; and, second, the relationship of the posterior branch of the radial nerve to the neck of the radius, when the forearm is placed in pronation and supination. The relationship of the branches of the radial nerve to the epicondylic ridge is important, because the exposure of the radial head can be made very much more satisfactorily if the surgical incision is extended about an inch and a half above the humeral epicondyle. The relationship of the posterior branch of the radial nerve to the neck of the radius is of utmost importance, because this branch recedes about one inch from its position in supination to its position in pronation.

In the study of the relationship of the branches of the radial nerve and muscles to the lateral epicondylic ridge of the humerus, the following structures are involved: the brachioradialis, the extensores carpi radialis longus and brevis, the lower end of the triceps brachii, the anconeus, the extensor digitorum communis, and the supinator radii brevis, and their nerve branches. It was noticed in the course of the study, that the nerve supply to the brachioradialis comes through a branch which emerges from the radial nerve, anterior to the epicondylic ridge about two and a half inches above the epicondyle. This branch divides into several smaller twigs which enter the deep surface of this muscle. The nerve of the extensor carpi radialis longus is given off about an inch more distal, also in front of the epicondylic ridge, and enters the muscle slightly above the epicondyle on the deep muscular surface. The nerve of the extensor carpi radialis brevis is often found crossing the epicondylic ridge from behind forward, emerging from the posterior branch of the radial nerve about one inch lower than the branch to the extensor carpi radialis longus. Sometimes the nerve to the extensor carpi radialis brevis appears to come

from the anterior division of the radial nerve. The nerve of the anconeus is given off very much higher in the posterior compartment of the arm. It is a branch of the inferior nerve of the medial head of the triceps brachii and it runs far behind the lateral epicondylic ridge. The supinator radii brevis receives its supply from the posterior branch of the radial nerve in its course through the supinator radii brevis muscle. The extensor digitorum communis and the other extensor muscles of the forearm are supplied by the posterior branch after its emergence from under the lower border of the supinator radii brevis muscle. Thus, an incision placed along the lateral epicondylic ridge and continued distally between the extensor radialis brevis and the extensor digitorum communis, will completely avoid all the important nerve branches to muscles in this region.

Several surgical approaches have been recently proposed. Boyd's approach consists in completely separating the anconeus and the supinator radii brevis from their ulnar insertion and then retracting the entire mass, including the posterior branch of the radial nerve, externally. This incision was found convenient in cases where the entire upper third of the radius and the ulna had to be exposed. However, when only the head of the radius has to be approached from the ulnar side, the radius is found deeply situated and more difficult to reach. A very good approach was described by Cadenat. He placed the incision between the extensores carpi radialis longus and brevis. It is known that it is easy to separate those two muscles at the level of the elbow, and, by separating them, easy to expose the posterior branch of the radial nerve as it enters the supinator radii brevis. In this manner, the preliminary exposure of the posterior branch avoids injury to this nerve. In making this incision it was found that the exposure of the head of the radius between the two radial extensors of the wrist made it more difficult to reach the head, and might also lead to injury of the nerve of the extensor radialis brevis, since this muscle often receives its nerve supply from the anterior branch of the radial nerve. Key and Conwell advise a straight lateral incision between the brachioradialis and the extensor carpi radialis longus. This approach may endanger the nerve supply to the extensores carpi radialis longus and brevis, if the incision is extended proximally.

In the anatomical study of a safe incision to the head and neck of the radius, the posterior branch of the radial nerve was exposed and its position in pronation and supination noted. Figure 1 illustrates the elbow, exposed through an incision running along the lateral epicondylic ridge, then through the posterior part of the lateral ligament of the elbow joint and through the orbicular ligament, down to the space between the extensor carpi radialis brevis and the extensor digitorum communis. This incision, with the forearm in supination as shown in the insert, is made posterior to the brachioradialis and the extensores carpi radialis longus and brevis, and avoids the nerve branches supplying these muscles. For simplification, the posterior motor branch of the radial nerve and the anterior sensory nerve are presented more prominently than they are in

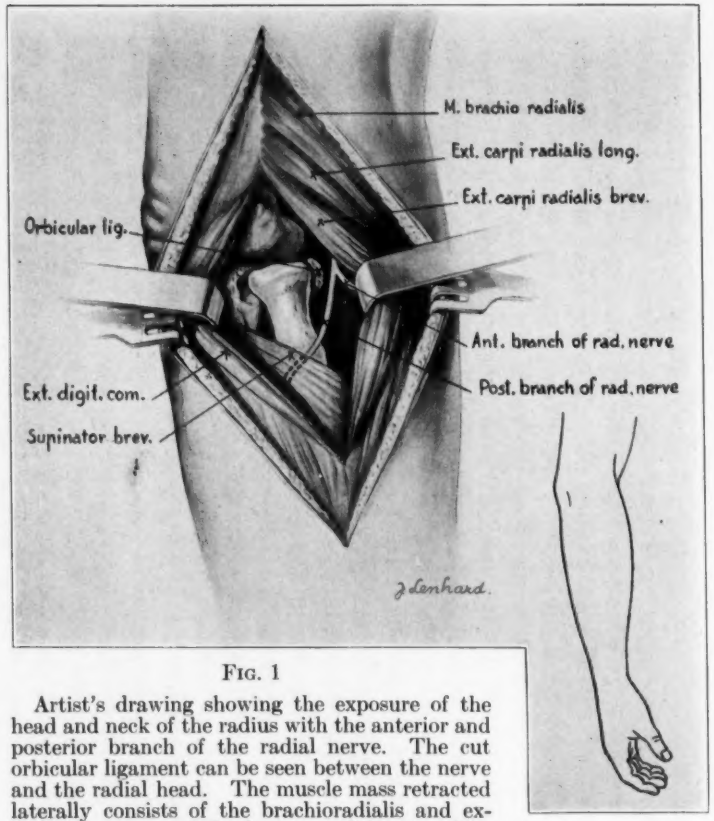

FIG. 1

Artist's drawing showing the exposure of the head and neck of the radius with the anterior and posterior branch of the radial nerve. The cut orbicular ligament can be seen between the nerve and the radial head. The muscle mass retracted laterally consists of the brachioradialis and extensores carpi radialis longus and brevis. The medial mass contains the extensor digitorum communis. The oblique fibers seen in the depth of the wound represent the supinator radii brevis. Note the relation of the posterior branch to the head and neck of the radius, the forearm being in supination, as shown in the insert.

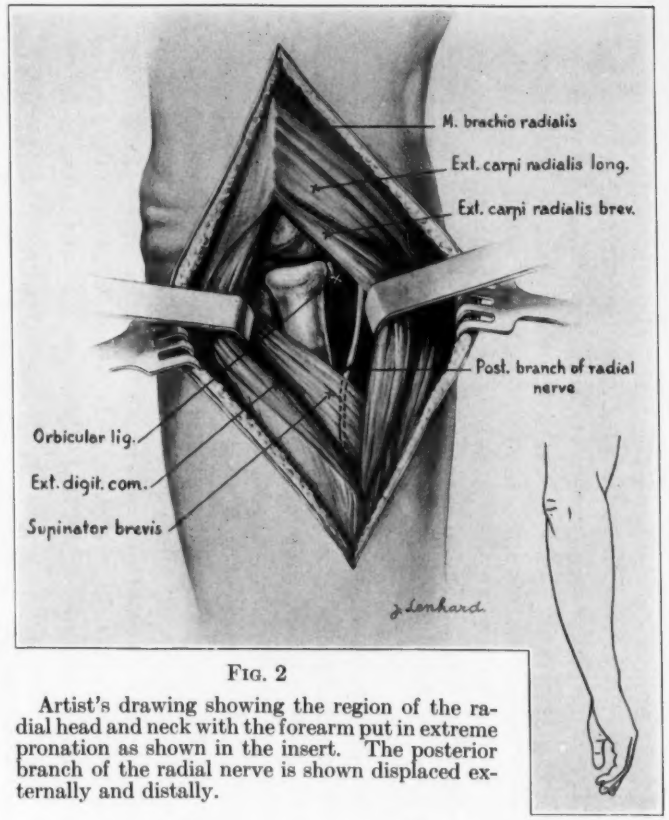

FIG. 2

Artist's drawing showing the region of the radial head and neck with the forearm put in extreme pronation as shown in the insert. The posterior branch of the radial nerve is shown displaced externally and distally.

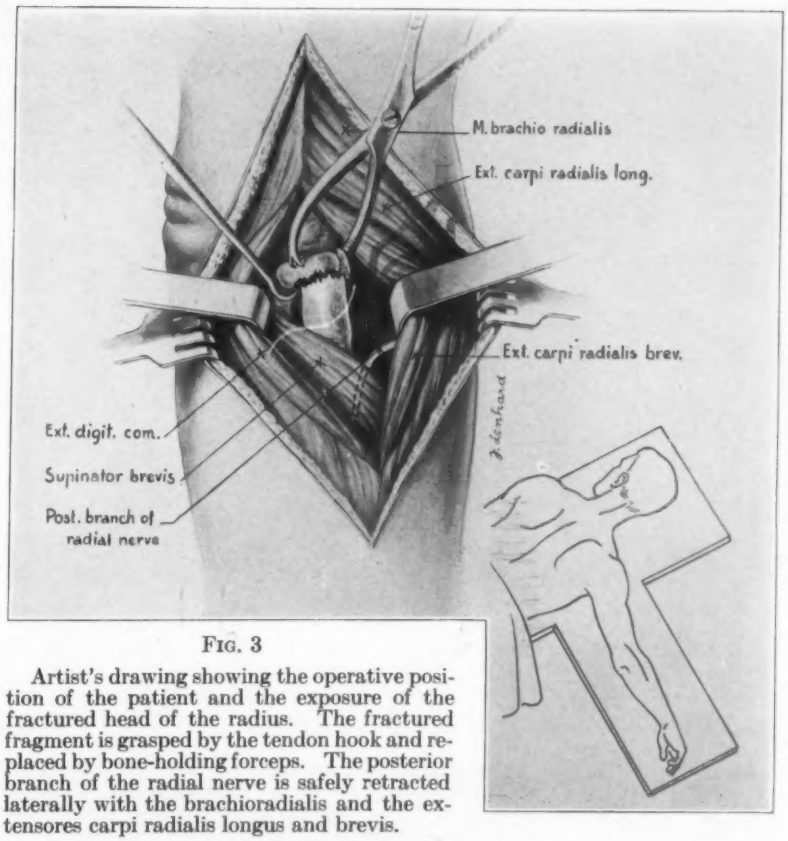

FIG. 3

Artist's drawing showing the operative position of the patient and the exposure of the fractured head of the radius. The fractured fragment is grasped by the tendon hook and replaced by bone-holding forceps. The posterior branch of the radial nerve is safely retracted laterally with the brachioradialis and the extensores carpi radialis longus and brevis.

reality to show clearly the relation of the motor branch to the radial head and neck. Figure 2 shows the same exposure, but with the forearm placed in complete pronation as shown in the insert. It can be seen that in pronation the posterior branch of the radial nerve becomes more distal in relation to the head of the radius and more external in relation to the neck. With these facts in mind it is not necessary to look for and expose the posterior branch of the radial nerve when a surgical incision is made. It is only necessary, with the forearm kept in complete pronation, to avoid placing the incision more than two inches below the articular surface of the head of the radius externally, and two and three-quarters of an inch below the same surface posteriorly.

The author's anatomical study of the approach was made in conjunction with treatment of fractures of the head of the radius in children, where, according to accepted opinion, replacement of the head is considered best.

OPERATIVE PROCEDURE

In the operative procedure developed on the basis of the anatomical study, the patient is placed, as shown in the insert (Fig. 3), in a prone posi-

FIG. 4-A FIG. 4-B

Anteroposterior and lateral roentgenograms of a fracture of the neck of the radius with lateral and anterior displacement.

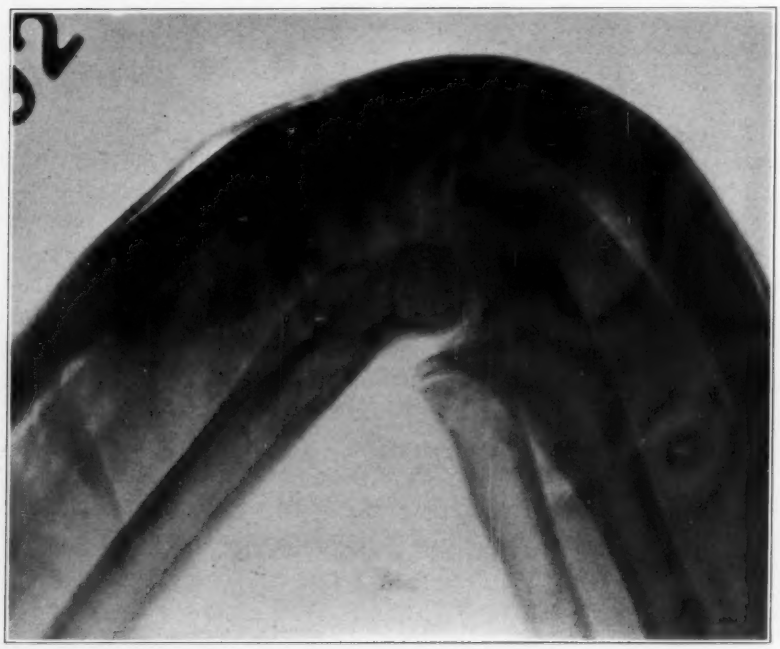

FIG. 4-C

Roentgenogram showing immediate postoperative reduction.

tion with the forearm in complete pronation, so that the little finger points upward. In this position, an incision is made over the lateral aspect of the elbow, starting directly over the epicondylic ridge about one and one-half inches above the epicondyle and extending the incision proximally for about two inches below the line of the radiohumeral joint. The incision is carried right down to the bone between the brachioradialis and the two radial extensors of the carpus laterally, and the extensor digitorum communis medially. The first mass of muscles is retracted laterally and the extensor digitorum communis is retracted medially. The supinator radii brevis muscle is identified in the depth. The radial neck and head are exposed. At this stage of the operation it is usually found that the fractured head is displaced forward, and that it is very difficult to grasp and extract it from the depth. A tendon hook can be used to catch the fractured surface of the displaced head and bring it sufficiently near the surface for a bone-holding forceps to secure it. As soon as the head is caught in this position, it is easy to replace it on the fractured neck, and to impact it firmly. Once the head is placed in this position, flexion and extension of the forearm, as well as pronation and supination, do not seem to displace it. The soft tissues are then sutured over the replaced head, and the arm is immobilized in a position of flexion and supination, for a period of two to three weeks.

Mayer has stated that, for operation on the head of the radius, the prone position of the patient with the forearm in complete pronation, and

FIG. 4-D

FIG. 4-E

Anteroposterior and lateral roentgenograms taken ten months after operation.

the incision placed as described above, has been used by him with great satisfaction for the past several years.

ILLUSTRATIVE CASE HISTORY

A fourteen-year-old boy (No. 77714) admitted to the hospital on July 6, 1939, fell six days before onto a concrete ledge of a swimming pool and injured his left elbow. The elbow became swollen, flexion and extension almost impossible, and supination and pronation very painful. Roentgenograms (Figs. 4-A and 4-B) showed a fracture of the neck of the radius below the epiphyseal plate. The head was displaced externally and slightly forward and was out of contact with the humerus. On this date, through an incision made over the external aspect of the elbow the head was replaced, the orbicular ligament sutured, and the forearm immobilized in a posterior splint for three weeks. Postoperative roentgenogram (Fig. 4-C) showed good realignment. Subsequent examination on May 22, 1940, ten months after the operation, showed a good anatomical result (Figs. 4-D and 4-E). Functionally the elbow was normal, the carrying angle was normal, pronation and supination were complete; flexion and extension of the elbow were equal to the normal side, and no atrophy of the muscles could be seen.

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SPINAL EXTRADURAL CYST ASSOCIATED WITH KYPHOSIS DORSALIS JUVENILIS *

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Non-parasitic, extradural, spinal cysts are so rarely encountered that when Elsberg, Dyke, and Brewer, in 1934, presented four cases found among 250 records of spinal tumors they believed that their report on this condition was the first published. This was closely followed by an extremely interesting paper by Lehman, who found three cases, previously reported by Schlesinger in 1898, Krauss in 1907, and Mixter in 1932, and added two cases of his own.

It remained for Cloward and Bucy in 1937 to correlate the presence of these cysts with the well-known deformity of the adolescent thoracic spine, kyphosis dorsalis juvenilis. The latter condition, long recognized as Scheuermann's disease, or occupational or apprentices' scoliosis, has been referred to commonly as vertebral epiphysitis, without any real evidence to indicate the underlying pathology. Cloward and Bucy demonstrated that, with one exception, all reported cases of extradural cysts of the spinal cord, which gave rise to symptoms during adolescence, were associated with deformities of the thoracic spine, usually a kyphosis of the type seen in Scheuermann's disease. The presentation of these authors leaves little doubt as to the relationship which exists between these benign extradural cysts and the associated vertebral condition, and makes a distinct contribution to the pathology of kyphosis dorsalis juvenilis. Aside from clearing up a difficult and vaguely understood condition, the thesis of these authors takes its place in modern medicine as an example of brilliant clinical reasoning.

Schanz and Scheuermann were among the first to describe the kyphotic deformity, seen in adolescents, which is almost always limited to the dorsal spine, and is rounded in type because of the partial collapse of several contiguous vertebral bodies. The process is self-arresting. The characteristic changes in the vertebral bodies are confined to the anterior part of the superior and inferior surfaces with a stepladder notching arrangement which may become wedge-shaped in the later stages. If allowed to progress, the condition becomes fixed, and may not be changed during the life of the patient. It was thought originally that the disease was a form of vertebral epiphysitis, although no direct evidence of such primary involvement could be demonstrated. The most rational explanation, to date, is that advanced by Cloward and Bucy. They believe

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TABLE I

RECORDED CASES OF SPINAL EXTRADURAL CYSTS

Case No.	Date Reported	Author	Age	Duration of Symptoms	Sex and Color	Location of Cyst	Dilatation of Spinal Canal	Results and Comments
1	1898	Schlesinger	?	?	?	Mid-thoracic	?	Patient died from multiple sclerosis. Post-mortem findings
2	1907	Krauss	46	13½ months	M.	3rd to 6th thoracic	?	Progress of disease arrested, but patient a helpless invalid
3	1932	Mixter	26	13 years	M.	3rd to 7th thoracic	?	No improvement
4	1934	Elsberg, Dyke, Brewer: Case 1	12	3½ years	M.	5th to 12th thoracic	Present (x-ray)	Great improvement, but not complete cure; previous scoliosis much more marked
5	1934	Elsberg, Dyke, Brewer: Case 2	15	3 months	M.	6th to 9th thoracic	Present (x-ray)	Cure
6	1934	Elsberg, Dyke, Brewer: Case 3	15	9 months	M.	4th to 9th thoracic	Present (x-ray)	Slight improvement
7	1934	Elsberg, Dyke, Brewer: Case 4	16	2 years	F.	Mid-thoracic	?	Almost complete cure
8	1935	Lehman: Case 1	12	3½ months	M. C.	6th to 8th thoracic	Present (Operation)	Cure; kyphosis
9	1935	Lehman: Case 2	17	9 months	M. C.	6th to 10th thoracic	?	Cure; kyphosis
10	1936	Cloward	43	2 years	M. W.	10th thoracic to 5th lumbar	Present (x-ray)	Almost complete cure
11	1936	Peet and Kahn	12	2 months	F. W.	9th thoracic to 4th lumbar	Present (Operation)	Cure
12	1937	Kelly	15	5 months	M.	6th to 8th thoracic	Present (x-ray)	Cure
13	1937	Cloward and Bucy	20	6 years	M. W.	7th to 9th thoracic	Present (x-ray)	Almost complete cure
14	1937	Mayfield and Spurling *						
15	1937	Teachenor *						
16	1939	Robertson and Graham	14	6 months	M. C.	7th to 9th thoracic	Present (x-ray)	Cure
17	1941	Adelstein	15	5 months	F. W.	5th to 7th thoracic	Present (x-ray)	Cure; previous kyphosis increased

* Quoted by Cloward and Bucy.

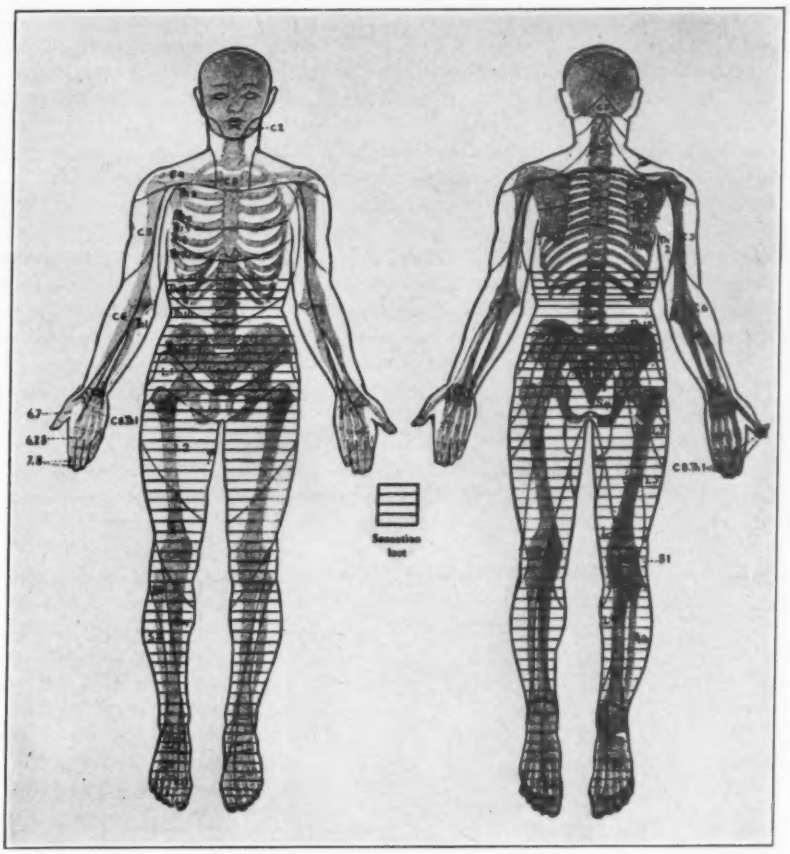

FIG. 1

Diagram shows the loss of cutaneous sensation below the eighth thoracic dermatome.

the kyphosis associated with extradural cysts is due to impaired venous drainage of the vertebral bodies from compression of these channels by the cysts. The cysts themselves are explained as congenital diverticulae of the dura and arachnoid at the exit of a spinal root.

To date, sixteen cases of this syndrome have been recorded (Table I). Since these patients, in the main, respond favorably to surgical intervention, the need for early recognition must be emphasized. The case presented here has been followed for over two years and demonstrates that early intervention with removal of the extradural cyst may result in complete cure with apparent arrest of the kyphotic deformity.

CASE REPORT

M. C., No. 547–931, a fifteen-year-old Mexican girl, was admitted to the Neurological Service of the Los Angeles General Hospital on July 2, 1937, complaining of severe weakness in both lower extremities with loss of bladder control. Some five months prior to the hospital admission she had first noticed beginning weakness in her legs, starting in the left foot. At no time had there been any pain or disturbed sensation in the form of tingling

or paraesthesia. During the month of June, 1937, walking became so difficult that patient could take but a few steps at a time. The family had noted that the child was rapidly becoming round-shouldered and had attempted to correct her posture by constantly advising her to stand erect. At the time of hospital admission the child could no longer walk without support.

The history otherwise was quite negative. The child had always enjoyed good health with no past history of any serious ailments, operations, or accidents.

Examination revealed a slender girl with a marked degree of rounded kyphosis of the mid-thoracic spine. The cranial nerves were entirely normal, and the upper extremities presented normal strength and intact sensation. There was a marked spastic paraplegia with little or no strength in the lower extremities and patient could scarcely move either leg up off the bed for even a short distance. Below the level of the eighth thoracic segment there was a loss of sensation of pain (Fig. 1). Position and vibratory sensibilities were entirely absent below the twelfth dorsal dermatome.

The lower tendon reflexes exhibited marked hyperactivity and there were bilateral Babinski signs as well as the associated Gordon, Oppenheim, and Chaddock signs. Ankle clonus was obtained on both sides. The patient could not walk.

The spinal-fluid examination revealed an initial pressure of 80 millimeters of water. The Queckenstedt test, compression of the jugular veins, caused no perceptible rise in the manometer level even on bilateral compression. The fluid was clear but definitely xanthochromic, with a cell count of eleven lymphocytes and an increase in the globulin content by Pandy's test.

FIG. 2

Lateral roentgenogram shows marked kyphosis centering at the sixth and seventh thoracic vertebrae.

Roentgenographic examination revealed a curved kyphosis of the vertebral bodies in the mid-thoracic region centering at the sixth and seventh vertebrae (Fig. 2). This was associated with an irregular narrowing of the superior and inferior margins of the vertebral bodies anteriorly. The anteroposterior views indicated a narrowing of the pedicles of the fifth to the eighth thoracic vertebrae with definite spreading of the interpedicular spaces (Fig. 3). From the roentgenographic standpoint the condition was recognized as juvenile vertebral epiphysitis.

The diagnosis of a localized lesion at the level of the sixth dorsal vertebra was made, although the exact relationship of the roentgenographic findings to the possible underlying pathology was not appreciated at the time.

Operation

On July 19, 1937, a

laminectomy was performed, removing the spines and arches of the fifth, sixth, and seventh thoracic vertebrae. At the level of the sixth thoracic spine a large extradural cystic tumor was found, filling the spinal canal and extending easily two full segments. The upper and lower limits of this cyst were uncovered and the mass was gently peeled away from the dura. The entire tumor was found to be extradural with an apparent point of origin from the left, sixth, thoracic root. The dura was opened at this point to visualize clearly the relationships in this pathology. The left sixth thoracic root was cut, and the neck of the cyst was tied and divided at its exit in the corresponding intervertebral foramen. This allowed the removal of the cyst *in toto*. The dura was closed with one silk suture, and the rest of the wound closed in layers in the usual manner.

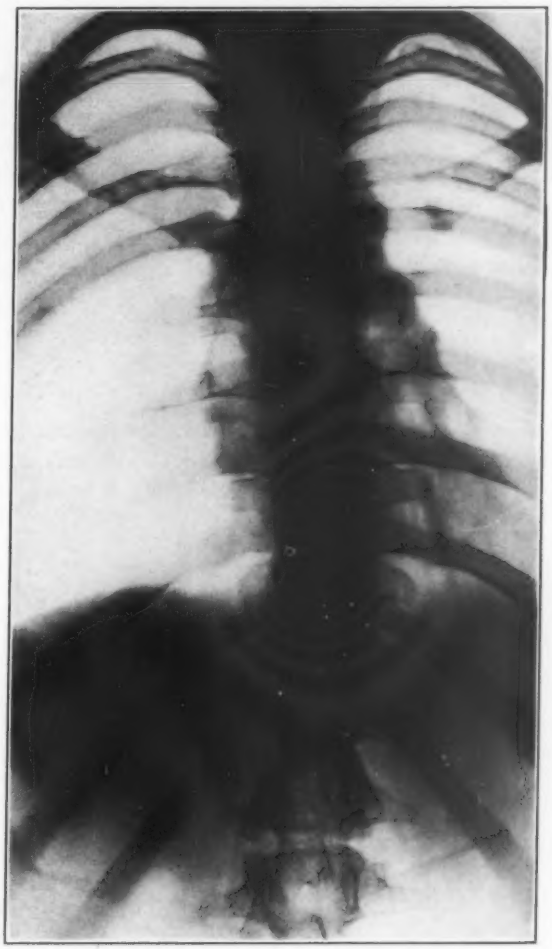

FIG. 3

Anteroposterior roentgenogram indicates marked spreading of the interpedicular spaces from the fifth to the eighth thoracic vertebrae.

Postoperative Course

The patient enjoyed an extremely smooth convalescence with rapid return of motor power in the legs. She was able to walk when she left the hospital, and has been kept under observation to date in the Neurological Out-Patient Department. She now appears to have completely recovered her motor and sensory powers in the lower extremities. The reflexes in the legs have remained rather hyperactive. The rounded kyphosis in the mid-thoracic region became somewhat more pronounced, but now appears to have reached its maximum degree of deformity, and has remained stationary for a number of months. The child has returned to school with no further difficulty.

Pathological Examination

Grossly, the specimen consisted of a saccular mass almost 4.5 centimeters in length (Fig. 4). To its surface was attached a small mass of fat. On opening the sac it was found to contain a blood clot and some fluid. The wall of the sac was thin but showed some variation in thickness.

Microscopically, section through the cyst wall showed loose connective tissue containing a few blood vessels (Fig. 5). No evidence of epithelial tissue could be determined. The diagnosis was made of an extradural cyst of undetermined etiology.

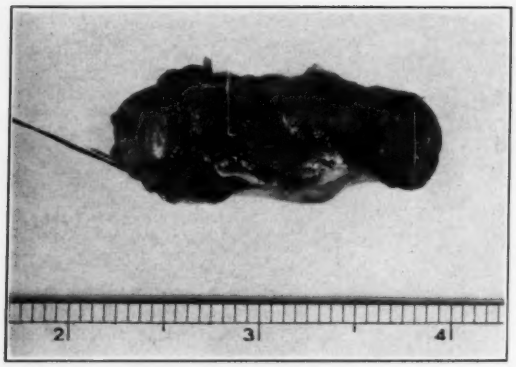

FIG. 4

Gross specimen of spinal extradural cyst after its removal from the mid-thoracic spinal canal. (Actual size.)

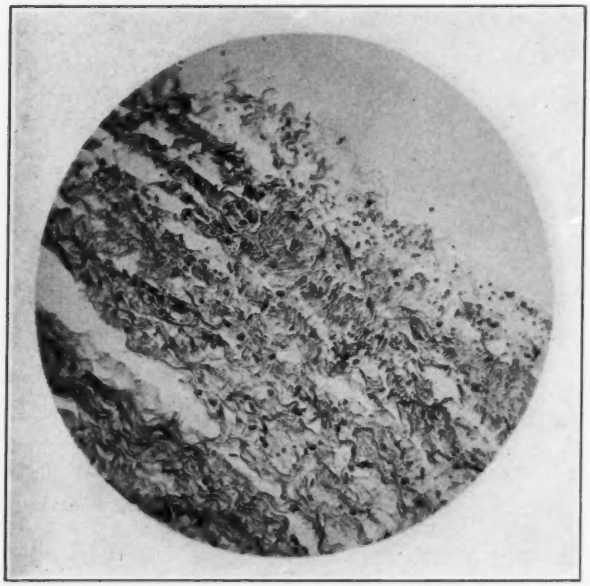

FIG. 5

Section through cyst wall showing loose connective tissue with a few blood vessels. There is no evidence of epithelial lining. (× 95.)

DISCUSSION

When Elsberg, Dyke, and Brewer published the records of their four cases in 1934, they were unable to find their counterpart in the literature up to that time. They outlined a characteristic syndrome of compression of the spinal cord by an extradural cyst including the following: "*The individual is an adolescent with the history and symptoms of a progressive spastic paraplegia. Pain is absent or is not a prominent symptom. The objective disturbances of sensibility are slight and their upper level is in the mid-thoracic region, usually at the sixth or seventh thoracic dermatome. The manometric tests demonstrate a subarachnoid block with the characteristic spinal fluid changes of cord compression. Measurements on anteroposterior x-ray films show that the interpedicular spaces of three or more vertebrae somewhere between the fourth and the tenth thoracic vertebrae are enlarged. The pedicles of the affected vertebrae especially those of the sixth, seventh and eighth, are narrowed and atrophic.*" This clinical picture is an accurate portrayal of a patient suffering from an extradural cyst associated with a progressive kyphotic deformity of the thoracic spinal column. In addition to the neurological picture there must also be emphasized the associated vertebral deformity which is now recognized as part and parcel of the syndrome, and which is constant in all but one of the cases reported to date.

A good résumé of this condition has been recently made by Kelly, who reviewed eleven cases and added one operated upon by Jefferson. This case, typically, occurred in a boy aged fifteen, who showed progressive motor weakness of the lower extremities, moderate sensory impairment, and roentgenographic evidence of enlargement of the spinal canal, together with thinning of the pedicles. The extradural cyst was removed, and the boy made a complete recovery.

The location of these extradural cysts in the dorsal region is extremely constant, and the reason is rather difficult to explain in the light of the present known pathology of the condition. Additional patients have recently been operated upon by Teachenor, Mayfield and Spurling, Peet and Kahn, and Robertson and Graham. There have been several detailed theories attempting to explain the presence of the cyst either as a congenital diverticulum from the dura or as a herniation of the arachnoid through a defect in the dura. Since Mayfield and Spurling demonstrated the direct communication between the cysts and the subarachnoid space, the herniation theory has been favored by several observers. This, of course, can be entirely reconciled with the typical structure of these cysts, which contain fibrous tissue, such as is seen in the dura, and epithelial cells similar to those found in the arachnoid. The cyst wall in our case revealed no endothelial lining.

From the neurological examinations alone it is quite impossible to differentiate preoperatively this type of lesion from any other form of tumor causing spinal-cord compression. Gradually increasing paraplegia, with little or no pain, and severe impairment of position sense and deep sensibility make up the usual and typical picture seen when the patient is first examined.

The spinal-fluid examination usually indicates a fairly complete subarachnoid block. The total protein content of the fluid is generally increased, and the fluid itself is apt to be xanthrochromic in color, depending upon the completeness of the block. Where the possibility of a cerebrospinal block cannot be definitely established, the injection of lipiodol is indicated, although this has been found necessary in only five of the cases described.

The most interesting changes seen in this condition are those revealed by roentgenograms of the thoracic spinal column. There is a definite increase in the size of the spinal canal shown on the anteroposterior views. The so-called interpedicular spaces are definitely enlarged and striking measurements are quoted by Elsberg, Dyke, and Brewer, indicative of pathognomonic erosions at the level of the spinal cyst. The pedicles themselves may be reduced to mere shells or may be only flattened or reduced in thickness. Alterations in the vertebral bodies have been discovered in every instance. The earliest changes are in the nature of rounded erosions of the anterosuperior and anteroinferior surfaces. This erosive process continues, producing notching or stepladder defects in several vertebral bodies in the mid-thoracic region.

The involved bodies may finally collapse anteriorly, producing a wedging with the appearance of a smooth, rounded kyphos. The lesion in the bodies usually coincides with the level of the extradural cyst. As previously indicated, these vertebral changes are quite secondary to the spinal cysts due to the venous stasis, caused by compression of the channels draining these bodies. Theoretically, and practically, removal of the cyst should prevent a further breakdown and arrest of the process. This will have to be further observed before any final conclusions may be drawn, although from the cases reviewed to date the kyphotic deformity rapidly reaches a maximum degree following removal of the cyst, and no further breakdown of the vertebral bodies takes place.

An adolescent male or female with a rounded kyphos, presenting a progressive weakness of the lower extremities, together with changes in the vertebral bodies of the mid-thoracic spine as seen in kyphosis dorsalis juvenilis, delineates a fairly characteristic clinical picture indicating the presence of an extradural spinal cyst. The mild progressive sensory changes, the involvement of the sphincters, and finally the establishment of a cerebrospinal-fluid block, corroborate the diagnostic impression. The widening of the spinal canal, together with the increased measurements made visible by the erosion of the interpedicular spaces, is all the additional evidence necessary to warrant exploratory laminectomy.

SUMMARY AND CONCLUSIONS

1. A case of extradural spinal cyst associated with kyphosis dorsalis juvenilis is reported.

2. Sixteen other cases of spinal extradural cysts collected from the literature are presented.

3. The clinical picture of an adolescent with progressive paraplegia, together with erosion of the vertebral bodies in the mid-thoracic region as seen in kyphosis dorsalis juvenilis, is pathognomonic of an extradural spinal cyst.

4. All cases of kyphosis dorsalis juvenilis should be carefully examined for evidence of spinal-cord compression and for roentgenographic evidence of enlargement of the spinal canal.

5. The deformity seen in kyphosis dorsalis juvenilis with extradural cyst results from venous stasis secondary to the presence of the cyst.

6. The etiology of kyphosis dorsalis juvenilis unassociated with an extradural cyst is unknown.

7. Early surgical intervention with removal of the intraspinal cyst usually results in complete cure with relief of all signs of spinal-cord compression and prompt arrest of the kyphotic deformity.

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FRACTURES OF THE TIBIAL CONDYLES

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A large group of papers have been published in recent years in which fractures of the tibial condyles were reviewed in considerable detail. They have appeared in American, French, Latin-American, and German periodicals. All have given emphasis to the bad prognosis in such injuries, and to the frequent necessity for operative correction of irregularities in the articular surface caused by the depression or displacement of the condylar masses. Since, in general, the impression left by these papers was contrary to the experience of the writer, a further study of such cases was undertaken.

Between the years 1928 and 1939, 565 fractures of the tibia were admitted to the Mt. Sinai Hospital. Of these, sixty-one fractures in sixty patients, or 11 per cent., involved one or both condyles. Observations concerning the age, location, nature of trauma, and other clinical material do not differ in general from the standard descriptions, and so need not be repeated here. Of particular interest to the present investigation were, (1) the relationship between the type of the lesion and its prognosis, and (2) the effect of treatment on prognosis. In brief it was found that in a large series of cases representing all degrees of injury to the condylar mass, operative interference was very seldom indicated, and that conservative care plus time did not give the large percentage of bad results so often reported. Furthermore, it was found that remarkably good function could be recovered in the knee joint in spite of roentgenographic evidence of moderate compression of part of the articular surface.

For purposes of analysis the cases were divided into two major groups. Group I included those in which condylar fragments were not obviously displaced. Group II those in which condylar displacement was present. However, there is no sharp dividing line between the two groups. Some minimal displacement must occur whenever the joint surface is fractured. The distinction is one of degree rather than kind. Displacement of the fragment always occurs in at least two planes, horizontal and vertical, and may occur in three planes,—horizontal, vertical, and anteroposterior. When displacement in the vertical plane is most apparent, the term "depressed fracture of the condyle" is sometimes used, but since both elements are to some extent always present together, the term "displacement" is more general. Because of the special interest which pertains to the so-called depressed fractures, these are considered in a subgroup of Group II.

GROUP I

Simple or Comminuted Fractures without Displacement

This group consisted of twenty-two cases in which displacement could not be demonstrated by roentgenogram or was apparently minimal. Of these, five were comminuted, two were complicated by concurrent fracture of the head of the fibula, and one by fracture of the tibial spine. Treatment in the seventeen uncomplicated cases was chiefly by plaster immobilization for periods ranging from two to ten weeks. The time depended mostly on the linear extent of the fracture or the amount of joint injury, gauged by swelling, immobility, or tenderness. In most instances the plaster was applied from the groin to, and including, the toes, although in a few lesions of lesser severity, only from the groin to the ankle. The knee was held in extension or slight flexion (5 to 10 degrees). In one case adhesive strapping was sufficient for a small articular linear fracture; in another a simple bandage sufficed. Of the five cases in which comminution occurred, one was treated by traction and later by plaster immobilization. In another, plaster immobilization was maintained for ten weeks. The remainder were treated in the same way as were the simple fractures. Concurrent fracture of the head of the fibula or tibial spine did not noticeably influence the duration of treatment or the end result.

GROUP II

Fractures with Condylar Displacement

This group consisted of thirty-nine cases. In fifteen of these the vertical component of the displacement was prominent enough to be classified as a "depressed fracture". The treatment of these will be considered first. However, it must again be emphasized that in most, if not all, of the other cases of Group II some perceptible degree of depression of the condylar table occurred as a minor component of the displacement. In each of these fifteen cases some attempt was made to correct the deformity,—in the earlier cases under general anaesthesia, and in the later ones under local anaesthesia or by pressure on the setting plaster. In no instance of simple depression fracture in this series could evidence be found that any significant correction of surface irregularity had been obtained by manual reduction. In several instances, apparent improvement in the roentgenographic appearance was due to differences in the position of the extremity in reference to the film. Subsequent x-rays showed the original degree of depression. However, in two cases correction of the anterior angulation and posterior displacement was accomplished.

Thirty-one of the cases in Group II were treated, as were the cases in Group I, by means of plaster immobilization in extension or slight flexion. The most frequent duration of immobilization was between six and a half and seven and a half weeks, the time again varying with the linear extent of the fracture. The joint reaction had usually subsided before the plaster was removed. Although full weight-bearing was

FIG. 1

Case 8. Female, thirty-six years of age, was struck by an auto and suffered a depressed fracture of the right external condyle. She was immobilized in plaster and hospitalized for three days. Fourteen months later she had slight valgus, excellent function, and no disability.

FIG. 2

Case 10. Male, age forty-one, was struck by an auto and suffered a fracture of the left internal condyle with no displacement of the fragments. He was immobilized in plaster for six weeks and hospitalized for three months. Thirteen months later he had normal function and no deformity or disability.

FIG. 3

Case 13. Female, age seventy-three, fell to the ground and suffered a depressed fracture of the right lateral condyle, and also fractures of the shaft of the tibia and fibula. She was hospitalized for ten days and treated by bed rest and caliper brace. Two years later she had slight lateral mobility, but no limp or symptoms.

prohibited, there was no hesitation in discharging these patients on crutches. *In no instance could evidence be found of an increase in bone deformity demonstrable by roentgenograms after the primary injury and displacement,* or during the follow-up, even though several patients bore weight on the immobilized extremity within two weeks. In nine of these cases there were concurrent fractures of the head of the fibula, but this fact had no perceptible influence on the duration of treatment.

In certain exceptional cases, treatment was modified to suit the circumstances. In one case, where the fracture involved both the internal and external condyles, and showed very marked displacement and comminution, treatment consisted of traction by Kirschner wire through the calcaneum for four weeks. At the end of this time the bones were sufficiently united and the wire removed. This patient's knee was still functioning normally without deformity seven years later. In another instance, a widely displaced fragment of an external condyle was removed. This knee was seen nine years later. At this time motion was free, but, although the patient walked well with slight valgus, he could not tolerate average periods of weight-bearing, and was discomforted by constant crepitus when using the limb. Lane screws were used in one case (Fig. 5) to hold the fragments in place after open reposition. In another (Fig. 4) wire traction, applied through the calcaneum, was supplemented by plaster immobilization. In view of the functional end results demonstrated

FIG. 4

Case 16. Female, age forty-one, had a fracture of the right external condyle. She was treated by wire traction and plaster immobilization, and hospitalized for a little over a month. The other knee had been fused for tuberculosis in childhood. Eight months later she had good function and no instability.

FIG. 5

Case 23. Female, age forty-two, fell downstairs and suffered a fracture of the right external condyle, with separation of fragments. The fragments were held in place by a Lane screw and the knee was immobilized in plaster for ten weeks. Patient was hospitalized for five and one-half weeks. Almost eight months later she had restricted flexion and walked with a limp.

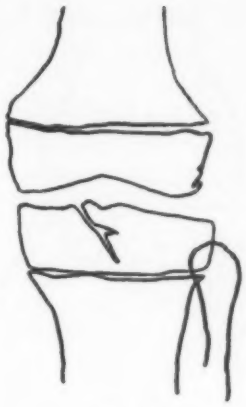

FIG. 6

Case 25. Male, twelve years of age, was struck by an auto and suffered a fracture of the left internal condyle with no displacement of fragments. He was immobilized in plaster for two weeks and hospitalized for one week. Eight months later he had normal function and no disability or symptoms.

in the present series, probably none of these cases would have been operated upon at the hospital today. In still another, a caliper brace was used for about six weeks, following nine weeks of plaster immobilization, in order "to prevent valgus". This was in 1935, but in retrospect this was an unnecessary precaution since the patient, followed for about a year, never became accustomed to the brace, and seldom walked with it. She walked easily when it was finally discarded. Lateral mobility, present in July 1936, had disappeared by October of that year.

HOSPITALIZATION

The duration of hospital stay in the treatment of fractures is impor-

TABLE I

PERIOD OF HOSPITALIZATION

Time	Group I	Group II
Accident room	9	9
2–7 days	4	7
8–14 days	3	6
15–21 days	0	3
3–5 weeks	2	2
Over 5 weeks	1	5
Total	19	32

FIG. 7

Case 32. Female, age seventy-two, was struck by an auto and suffered a depressed fracture of the left external condyle. She was immobilized in plaster, and after one week was transferred to another hospital. She also had arteriosclerosis.

FIG. 8

Case 34. Female, age fifty-five, fell downstairs and suffered a depressed T fracture with slight deformity, of the right external condyle. She was treated in the accident room and referred to private care.

FIG. 9

Case 49. Female, age forty-nine, was struck by an auto and suffered fractures of the right external condyle and the left internal condyle. There was slight displacement in the right, and a linear fracture line without displacement in the left. The right knee (shown above) was treated by plaster immobilization and the left by adhesive strapping. She was hospitalized for two days. There was no follow-up.

tant from the point of view of both the patient and the hospital. General time averages reduced to a simple mean are inadequate to interpret such statistical material properly. Table I is a more accurate analysis. Nine cases in which there were complications incidental to the original accident, but not directly related to the fractured condyle, are not included as they would falsify the interpretation of the subject in question. For example, some of the cases of multiple fractures, those complicated by bronchopneumonia, fractures occurring in patients with known cardiac conditions, patients transferred to other hospitals and not followed, and one hospitalized for injury to the spine are omitted from the statistics.

The relative shortness of the hospital stay of cases admitted to the wards as compared to the hospitalization of operative cases is obvious.

END RESULTS

Complete follow-up data was available for the evaluation of end results in thirty-three of the sixty-one fractures. It may be added that in the remaining twenty-eight fractures, observations, as far as they went, tended to confirm the conclusions arrived at. The degree of functional recovery found in most instances, which showed roentgenographic evidence of residual irregularities, was surprisingly good. (See, for example, Figures 1 and 4.) Either because of contraction of opposing ligaments, or through replacement of the depressed bone surface within the

joint by fibrous tissue, the degree of valgus or instability suggested by the roentgenographic appearance was never clinically demonstrable.

The present series of unselected cases, which show all degrees of injury, demonstrate that while in about 10 per cent. of Group I and 20 per cent. of Group II, lateral instability of the knee joint was present in the early weeks following the removal of plaster, it almost invariably disappeared or decreased to a minimum between six and twelve months after fracture. This occurred with no after-treatment other than walking, and, in some instances, simple physiotherapy such as heat and massage. By the phrase "decreased to a minimum" is meant that no significant dysfunction or deformity was apparent while the patient was active. In other cases no significant lateral instability could be elicited at the knee joint at any time during the follow-up period. In only three cases was valgus or significant lateral instability noted as a deformity in the end result. One of these had been operated upon. In neither of the other two did the slight valgus interfere in any way with the function of the extremity.

One would suspect that in these fractures, occurring as they do for the most part in patients of middle age or older, traumatic arthritis would be a prominent disabling sequel. On the contrary, this appeared in only two cases. In one case, a female who sustained a fracture at the age of fifty-eight, showed evidence of generalized osteo-arthrosis five years later at the age of sixty-three. Both knees among other joints affected showed about equal involvement, and both were equally symptomatic. The fractured knee was normally mobile; there was no limp and no valgus deformity. In general, where symptoms of traumatic arthritis did not persist from the time of recovery, they did not appear in any of the fractures examined after periods ranging from two to nine years. Traumatic arthritis, when it occurred at all, manifested itself in the first year.

The only dysfunction which did remain in a number of cases was restriction of flexion to 80 or 90 degrees at the time of the last examination. This was rarely a noticeable disability in older persons, and usually tended to improve with time, if the patient was active.

Comminution or splintering of the adjacent shaft bore no apparent relation to the final outcome other than that of time,—the greater the extent of the fractured surface, the longer the period of recovery. In one case, in spite of severe comminution and displacement, and abnormal usage of the joint because of an old fusion of the opposite knee, due to tuberculosis, the functional result was good eight months later. Concurrent fracture of the head of the fibula which occurred in nine cases, did not, *per se*, adversely influence the course or end result. Fractures of the external condyle did not differ in their final status from those of the internal.

CONCLUSIONS

Sixty-one fractures of the tibial condyles have been reviewed with special reference to the end results in relation to type of fracture and treatment in thirty-three cases. The following conclusions were demonstrated:

1. Operative replacement of the depressed or fractured condyle is seldom necessary except in cases of extreme displacement, as satisfactory functional results are obtained even when considerable irregularity of the condylar tables persists.

2. Lateral instability of the knee joint is a temporary phenomenon in most of these cases, and decreases gradually during the recovery period. It cannot be considered permanent until the end of one year, and, *per se*, requires no treatment.

3. A slight valgus or varus deformity or even slight lateral instability is not incompatible with excellent function of the extremity, and the deformity does not progress.

4. Plaster or brace immobilization must be maintained until roentgenograms show evidence of satisfactory union. In most instances, six to seven weeks is sufficient. Prolonged immobilization detracts from the freedom of the joint and is unnecessary as a preventative of deformity.

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SOME ORTHOPAEDIC RELATIONSHIPS OF NEUROFIBROMATOSIS*

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Dorland briefly defines a neurofibroma as "a connective tissue tumor of the nerve fibre fascicule, formed by proliferation of the perineurium and endoneurium", but this brief statement gives no hint of its numerous ramifications into many fields of medicine.

While neurofibromatosis itself shows only a few simple signs, its associations develop numerous complexities. They are frequently so striking that the primary condition is entirely overlooked. The common associations are:

1. Endocrine dyscrasias.
2. Mental changes.
3. Malignant transformations.
4. Skeletal changes (of interest to the orthopaedic surgeon).
   (a) Scoliosis.
   (b) Abnormalities of growth (usually hypertrophy).
   (c) Changes in bone structure.
   (d) Congenital pseudarthrosis in children.

This last relationship has only recently attracted attention, having been reported in 1937 by Ducroquet and in 1939 by Barber.

This paper is based on a study of four cases of localized hypertrophy, in all of which the diagnosis was confirmed by pathological study, and three cases of pseudarthrosis selected from a series of eight. These three were chosen because of familial evidence of neurofibromatosis, as well as the evidence in the cases themselves. In one of them the diagnosis was confirmed pathologically with interesting findings. The other five cases in our series all showed definite signs of neurofibromatosis.

LOCALIZED HYPERTROPHY

CASE 1. E. M., a Filipino engineering student, was admitted to Wesley Memorial Hospital, July 26, 1920.

He complained of difficulty in opening and closing his right hand. Flexion of the fingers caused a painful "snapping" located in the palmar region of the wrist. Extension repeated the process in reverse. Passive flexion and extension caused the "snapping" or "jumping", but this was not so painful. The condition had been present at intervals for several years. The second and third fingers were disproportionately large and had been so all his life as far as he knew.

The examination showed a palmar swelling from the mid-palmar region to a point one and one-half inches above the base of the palm. The swelling was soft, slightly tender, and somewhat fluctuant, but with no local heat. The second and third fingers were considerably longer and thicker than the normal, compared to the other fingers, and larger than the corresponding fingers on the left hand. The skin on these fingers was coarse in texture.

*Read at the Annual Meeting of the American Orthopaedic Association, Kansas City, Missouri, on May 8, 1940.

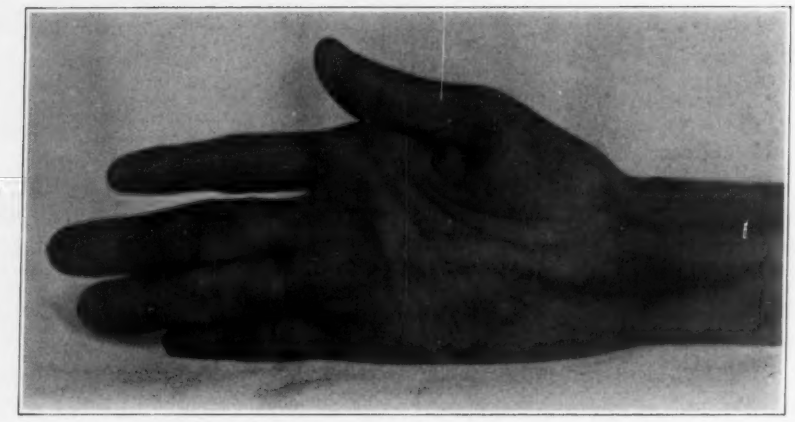

FIG. 1

Case 1. E. M. Postoperative photograph of the hand, showing the hypertrophy of the second and third fingers and swelling from the tumor at the base of the palm just above the line of incision. The change in the skin texture is seen down the middle of the palm.

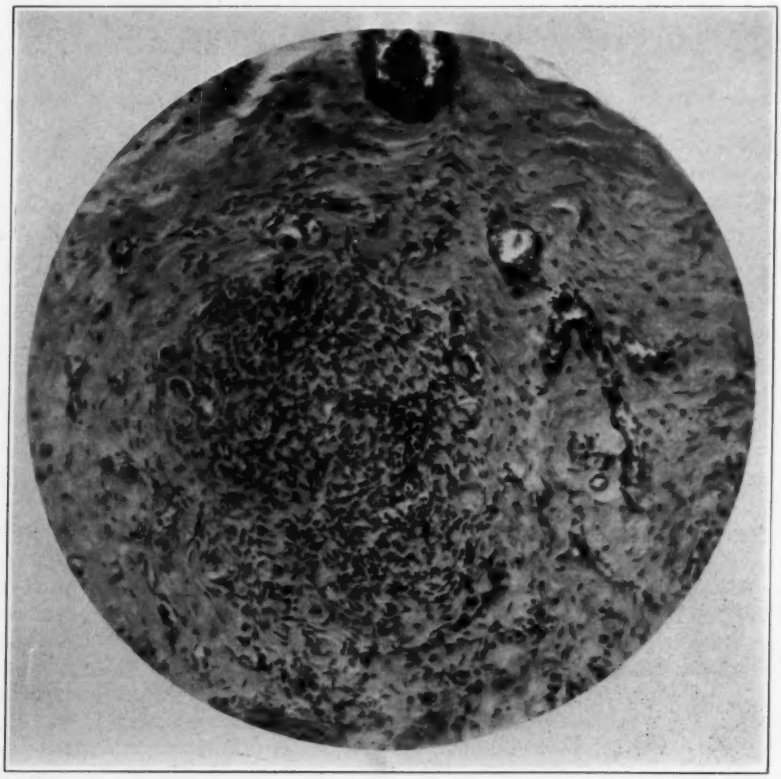

FIG. 2

Case 1. E. M. Low-power photomicrograph showing the fibrous tissue largely at the periphery of the field, with very little of the so-called "palisade" but some parallel arrangement of the elongated and narrowed nuclei, most noticeable in the upper left quadrant. The few vacuolations seen are presumably from degeneration of nerve fibers. This is an old mature type of tumor.

On attempted active flexion the fingers would stop at about midflexion, and, if the motion was continued, a distinct jumping could be seen and felt under the ligamentum carpi transversum. Pressure at this point prevented the motion and caused pain. A similar reaction took place on extension from the flexed position. These findings suggested a condition analogous to trigger finger,—that is, a thickening of the flexor tendons at the point where they passed under the transverse ligament.

On July 27, 1920, a three-inch longitudinal incision was made on the palmar surface of the wrist. Underneath the fascia a tumor was found, which extended from the middle of the palm into the wrist and was constricted by the transverse ligament into an hour-glass shape. This tumor was reddened, soft, and somewhat corded. At the proximal end it was continuous with the median nerve and appeared to be an expansion of it. It was realized at once that any attempt at removal might leave the hand worse; therefore, the transverse ligament was incised, and, after inspection of the flexor tendons which were normal, was sutured *under* the median nerve to relieve the pressure on the nerve. A small portion of the tumor was removed for microscopic study. The skin and fascia were closed *over* the nerve. Healing was prompt, and the motion of the fingers was normal afterward. For a while there was a small area of anaesthesia over the forefinger, but this eventually cleared up. The microscopic examination, reported by Dr. Zeit, showed a neurofibroma of the "*Ranken-neuroma*" type. The area of anaesthesia on the forefinger was interesting because that finger was not involved in the hypertrophic changes though its nerve fiber was involved in the fibromatous change. Evidently, also, in spite of the change, that fiber was still functioning so far as sensation was concerned.

CASE 2. M. P., aged twelve, was admitted to Shriners' Hospital, August 25, 1933, with the complaint of deformity of the right foot and leg. The child was said to be normal at birth, but deformity began at one or one and one-half years of age. The right leg was slightly bowed below the knee and the foot turned outward. The deformity had increased with growth, but did not cause marked disability. The right leg had been growing faster than the left; it was then one inch longer.

On examination it was found that the right foot was pronated, and that there was marked abduction of the forefoot at the mid-tarsal joint. The head of the astragalus was displaced inward almost directly below the internal malleolus. The heel projected backward more than normal and was rolled outward. The skin on the outer margin of the foot was loose, wrinkled, and thickened. In this same region and extending upward, there was a peculiar granular feeling to the subcutaneous tissue.

The muscles of the leg were all acting and of good power except possibly the posterior tibial. Sensation was normal in the skin of the foot. The right tibia was approximately one inch longer than the left. Brownish pigmented areas from one-quarter of an inch to two inches in size were scattered over the back and legs. In addition to the pigmented areas there were purplish naevi on the back, both of them in larger brown areas.

FIG. 3

Case 2. M. P. Photograph taken on admission shows pigmented areas on the back, the left buttock, and the legs. On the large spot below the left scapula there is also a small hemangiomatous naevus. Another lies lateral to it also in an area of pigmentation.

The enlargement of the heel below the right internal malleolus was the site of the plexiform tumor which was easily palpable under the skin. There was a one-inch lengthening of the tibia. The calf was poorly developed.

FIG. 4-A FIG. 4-B

Case 2. M. P. Photographs of the right leg show several typical pigmented areas, light ones just above the malleolus and about midway from the knee to the foot, and darker ones in the mid-calf region, and on the thigh.

There is marked lowering of the longitudinal arch with the prominence of the head of the astragalus easily seen. The foot is everted and the external malleolus has lost its normal prominence. The internal malleolus is masked by the fullness between the tibia and the tendo achillis which is the site of the tumor. The peculiar shape of the calf muscle is well shown.

The wrinkled loose skin near the heel extends from somewhat anterior to the malleolus to the outer side of the heel.

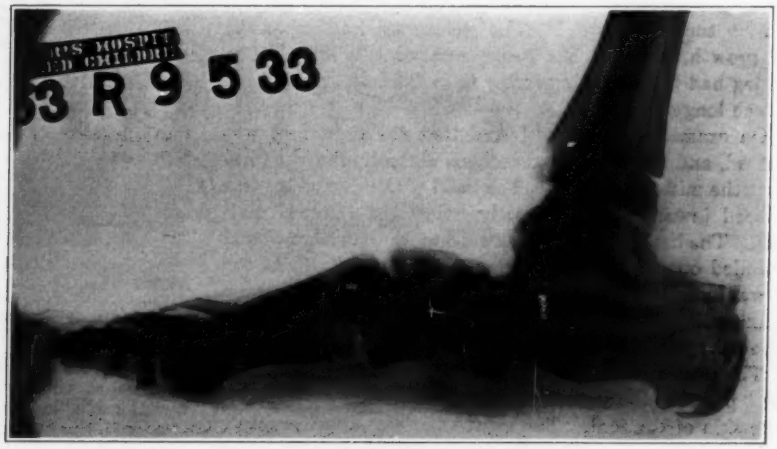

FIG. 5

Case 2. M. P. Roentgenogram shows the abnormal position of the astragalus with its axis almost straight with the tibia, its head rotated downward, and its posterior surface flattened, perhaps from weight-bearing in the faulty position. The lines of structure in the os calcis are altered. The entire longitudinal arch is lowered. The lower epiphyseal line of the tibia appears normal.

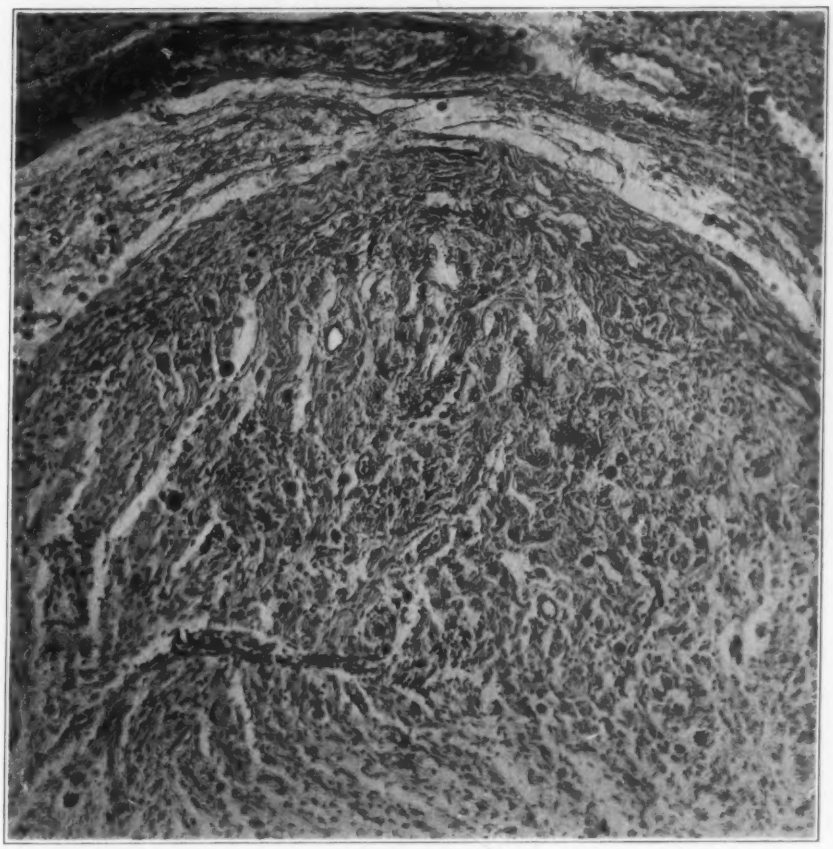

FIG. 6

Case 2. M. P. Low-power photomicrograph of about half a nerve fasciculus cut transversely shows the infiltration of fibrous tissue. There is very little "palisading" of nuclei though in the lower center area may be seen a small group. The nuclei are not markedly compressed. In the upper portion of the section a few fibrils appear to extend from the limiting membrane down into the fasciculus.

In the upper right hand corner is an arteriole whose walls are thickened and whose lumen shows a trace of a web. Possibly this is a beginning endarteritis. There are several areas of vacuolization.

The diagnosis was suspected neurofibroma or hemangioma.

A roentgenogram of the lateral view showed marked lowering of the longitudinal arch with displacement of the astragalar head; the anteroposterior view showed the scaphoid to be wedge-shaped and the foot markedly everted.

On September 7, 1933, an exploratory operation and biopsy was performed. A longitudinal incision, six inches long, extending upward from behind the internal malleolus, revealed a firm tortuous mass located in close proximity to the posterior tibial artery and vein but separate from them. It occupied the position of the posterior tibial nerve, but so far as it was dissected no normal nerve was seen entering the mass which could be palpated above the incision. The mass was covered by a definite sheath, and on opening this sheath the interior was found to consist of convoluted, hard, cordlike, solid, white fibers. From its character and position it was considered a neurofibroma and several small portions were removed for microscopic examination, but no attempt was made to remove the entire mass. Closure was made and healing was uneventful. The

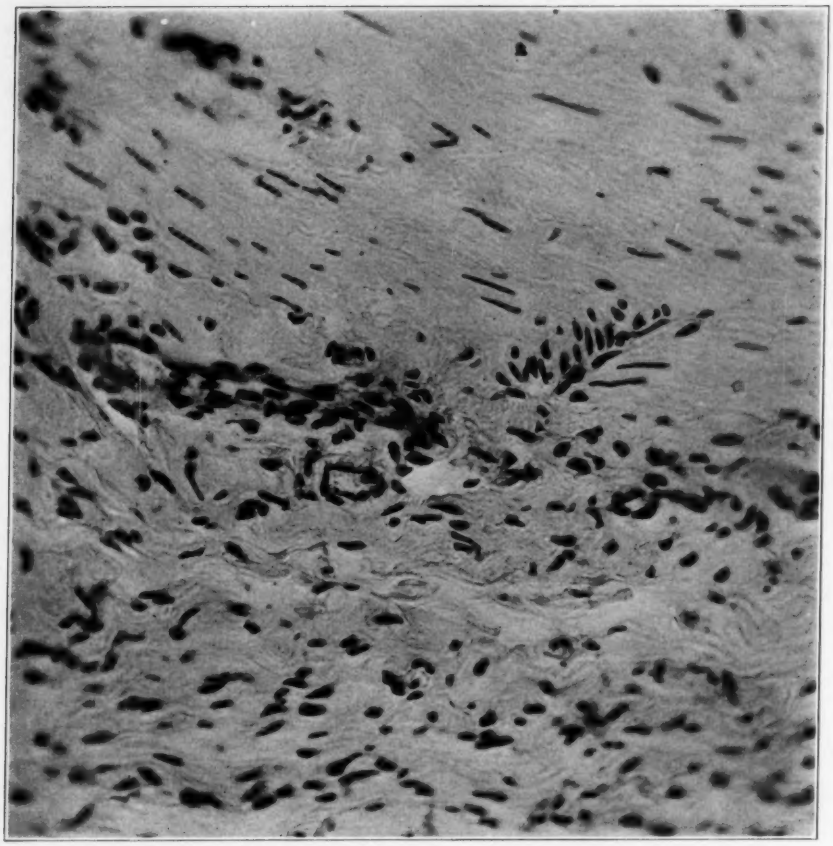

FIG. 7

Case 2. M. P. High-power photomicrograph illustrating the arrangement of the nuclei in the connective-tissue background. In the upper half the parallel arrangement is predominant, while in the lower half the arrangement is more in whorl formation. Slightly to the right of center the nuclei are definitely "palisaded". In the lower left-hand corner is a similar area, but the nuclei have been sectioned transversely.

pathological report was neurofibroma. Following this operation the skin was checked carefully for changes in sensation but none were found. Apparently the nerve was still functioning, but the portions removed were not large and the normal overlap may have taken care of the areas removed for examination.

CASE 3. D. D., aged eleven, was admitted to Shriners' Hospital, March 3, 1934, complaining of deformity of the right foot and leg.

The mother had noticed some deformity of the foot soon after birth, but it was not extreme, and she had not paid much attention to it. When the boy was about three years old, she noticed the right leg was growing faster than the left, and the deformity of the foot was increasing. The leg continued to outgrow the other and the limp became worse.

On examination the right foot was found badly everted and the longitudinal arch nonexistent. The astragalus seemed to be in normal relationship to both the tibia and scaphoid. The tarsal joints of the foot were very mobile and gave the impression that the ligaments were lax. This condition was especially noticeable in the subastragaloid and mid-tarsal joints. On the outer side of the foot the skin was loose and wrinkled, its

texture coarse and the lines deepened, a condition which extended almost to the toe. Back of the external malleolus there could be felt a tortuous, corded, plexiform tumor extending upward between the tendo achillis and the fibula. The right tibia was about two inches longer than the left. The calf muscle was not well developed. All the muscles had good power though it was difficult for them to exert it to the full because of the looseness of the tarsal joints. Skin sensation was normal. There were numerous areas of brown pigmentation on the legs, trunk, arms, and neck.

A roentgenogram showed a marked lowering of the longitudinal arch. The os calcis and the head of the astragalus were small and misshapen.

On March 15, 1934, the tumor was exposed through an incision back of the fibula.

FIG. 8-A FIG. 8-B

Case 3. D. D. Photographs show the eversion and abduction of the right foot and the increase in length of the right leg. The deformity shown in this foot was due to the very marked laxity of the tarsal joints, but was not a fixed deformity as shown in Case 2.

Across the heel and along the outer margin of the foot there is a sharply outlined area of change in the skin texture. The skin in this area was thickened, wrinkled, and loose, and the texture much coarser than in other areas.

Several areas of pigmentation are visible, one near the location of the head of the fibula, and three just above the level of the patella.

On the dorsal surface of the foot can be seen two flattish soft tumors. They are not the usual pedunculated variety seen in adults, but may be an early stage of these tumors. The area in which the plexiform tumor was found is shown by the fullness external to the tendo achillis. The fullness internal to the tendon was apparently due to the laxity of the tarsal joints which allowed the ankle to sag inward.

FIG. 9

Case 3. D. D. Roentgenogram of the lateral view of the right foot shows all of the tarsal bones to be misshapen and smaller than normal, whereas the tibia was two inches longer. This condition of the bones probably accounts for the laxity of the tarsal joints. There is a distinct mottling of the metatarsals and the row of tarsal bones adjoining them. The medullary canals of the metatarsals, with the exception of the first metatarsal, are distorted and irregular. The bones appear irregularly developed, rather than atrophic.

The epiphyseal line of the tibia is not distinct and is narrower than usual at his age. The longitudinal trabeculation of the tibia is much more pronounced than the transverse, which is characteristic of rapid bone growth. There are no lines of arrested growth.

This roentgenogram shows evidence of a distinct mixture of over and under development in the same member.

It presented a maze of cordlike convoluted fibers. A large portion of the structure was dissected out and removed. An arthrodesis between the head of the astragalus and the scaphoid was also done. Healing was uneventful.

The pathological examination showed a neurofibroma of a mature type. There was also a definite endarteritis present, shown not only as a thickening of the walls, but as a definite fibrous web extending across the lumen of several vessels. This was the first case in which the condition was found so definitely, and it may be of considerable importance.

At the time of discharge from the Hospital the skin of the foot and leg was carefully checked for sensory changes, but none was found. This is rather curious as a large amount of the neurofibromatous tissue was removed, and it seems as though there should have been some sensory change if the nerve were functioning. At his last visit three years later the discrepancy in the leg length was three inches, an increase of one inch.

CASE 4. L. McC., aged thirteen, was admitted to Shriners' Hospital, August 17, 1935, complaining of difficulty in walking on account of a deformity of the left leg and foot. The deformity consisted of a marked overgrowth of the lower leg, and distortion and extreme flaccidity of the foot. The father said that the foot was "turned outward" when the boy was born, but that the legs were of equal length. The patient began walking at two years of age, with the weight borne on the *inner* side of the foot. At that time there was an enlargement developing in the calf and around the heel which continued to increase. A few months later it was noticed that the left leg was growing faster than the right. This it has continued to do. About four years ago he developed a slight curvature of the spine which has increased rapidly.

On examination the foot was found to be dorsiflexed and rotated outward, with the heel drawn forward directly under the tibia. All the joints of the foot were extremely

lax so that the sensation was of the bones being loose in a bag of skin. The calcaneum and the tarsal bones all felt much smaller than normal. The skin of the foot posterior to the metatarsal region was loose, deeply wrinkled, and of coarse texture. Underneath the skin could be felt a mass of cordlike bands and nodules. The sensation was strikingly like a bag of angleworms. This condition extended two-thirds of the distance to the knee dorsally. The *left* tibia was approximately six inches longer than the right. Skin sensation was normal and the muscles were all acting, but weak.

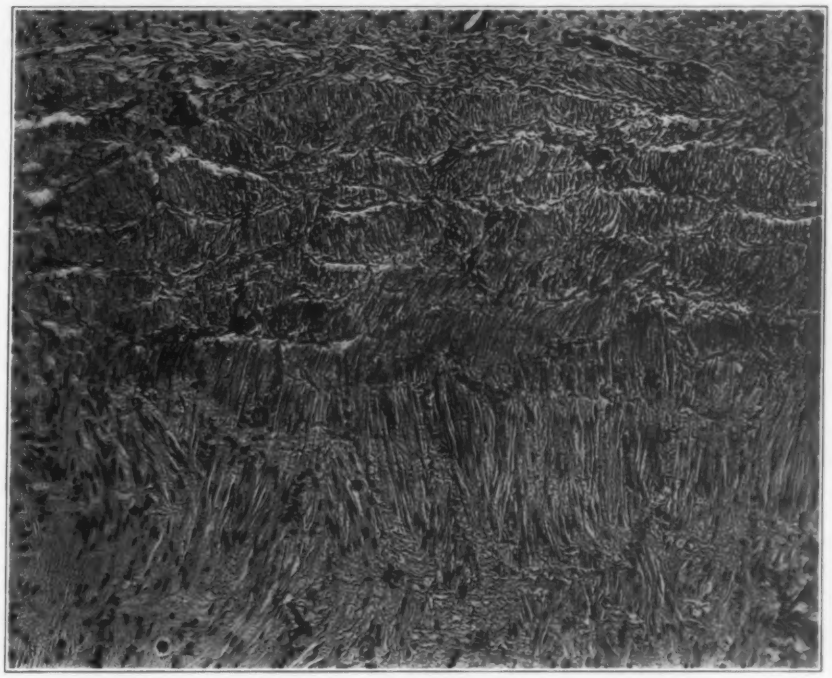

FIG. 10

Case 3. D. D. Low-power photomicrograph of section shows almost pure fibroma with very little evidence of nerve tissue. At the bottom there is what might be called a "streamline" arrangement while on the top the tissue is more irregularly arranged, but has a tendency toward whorl formation. The nuclei are elongated; there is some "palisading"; and a very distinct parallel arrangement. There is some vacuolization.

FIG. 11

Case 3. D. D. High-power photomicrograph illustrates an advanced fibrous replacement of the peroneal nerve. Note the parallel arrangement of the compressed and elongated fibroblasts. In the area near the center there is a distinct reticular appearance of the fibrous tissue.

FIG. 12

Case 3. D. D. High-power photomicrograph shows much more of the whorl arrangement than the streamline or parallel. There are several areas of vacuolization. However, the point of special interest is the two blood vessels near the center. In both the wall is much thickened. In the vessel on the right there is a distinct web of fibrous tissue extending across the lumen. The lumen itself is flattened from side to side as if the fibrous web is drawing the sides together. In the vessel on the left the web is more extensive, hiding more than half the lumen which is also narrowed from side to side. This is a definite endarteritis,—a condition which we have not found mentioned, but which may be of importance in accounting for certain findings in neurofibromatosis.

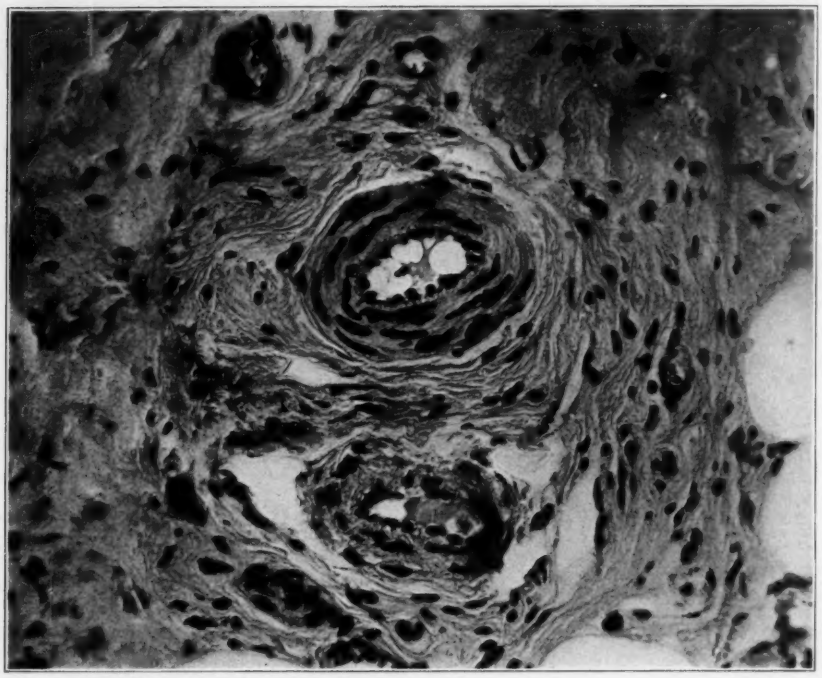

FIG. 12
(See page 117)

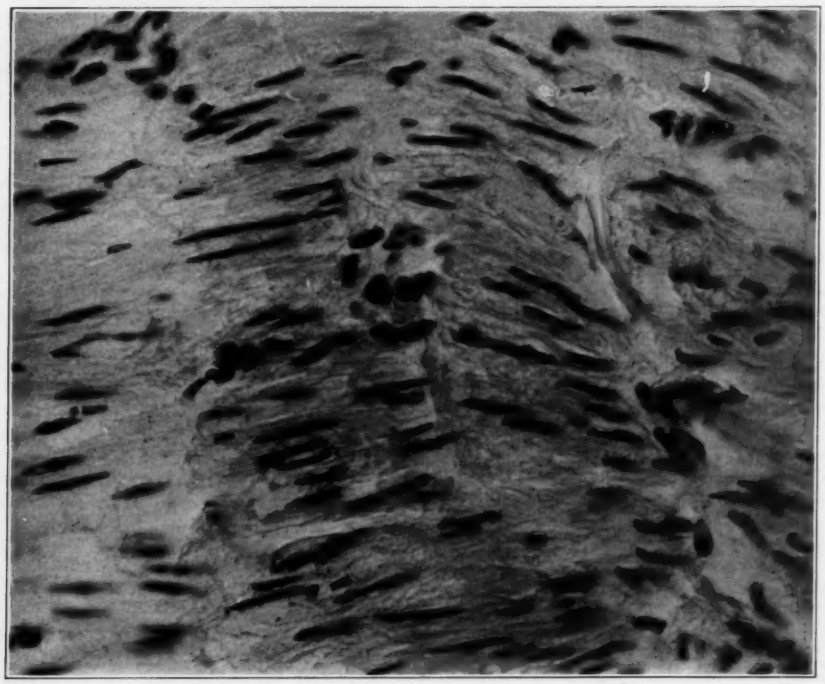

FIG. 11
(See page 117)

FIG. 13-A

Case 4. L. McC. Photograph of side view shows marked overgrowth of left lower leg with deformity and skin changes of the foot. Note also kyphoscoliosis. Pigmentary changes were present but not prominent in this case.

FIG. 13-B

Photograph of the front view shows the extreme overgrowth of the left leg below the knee. The tibia was six inches longer than on the right side. The elephantiasis was marked throughout the leg and the loose baggy condition about the heel is well shown.

FIG. 13-C

The kyphotic element of the spine deformity is well shown in this lateral view, also the extreme distortion of the foot and leg are obvious.

There is a definite pigmented area over the right scapula and another small one behind the trochanter. The condition of the skin over the tip of the nose can be best seen in this view.

FIG. 14

Case 4. L. McC. Roentgenogram of lateral view of the left foot. The distortion, underdevelopment, and displacement of all the tarsal bones, including the astragalus and os calcis, is most noticeable. The metatarsals and phalanges appear fairly normal in shape, but atrophied probably from lack of function. The os calcis and astragalus appear fairly hard even though misshapen.

The tibia is rather narrow and lacks the usual flare at the lower end. The cortex is thin but not excessively so. The epiphyseal line is narrower than normal and not distinct. There is little bone marking in the lower end, and the transverse lines of cessation of growth are absent unless there is a rudimentary one about an inch above the lower end.

The spine showed a marked scoliosis to the right in the dorsal region with its apex at about the sixth dorsal vertebra. The apex was sharp with a marked kyphotic element. There was some compensatory curve in the lumbar region though not so much as is usual with so marked a dorsal curve.

There were numerous brownish pigmented areas over the body. The skin of the face was somewhat red, suggesting a slight hemangiomatous birthmark.

Roentgenographic examination showed marked distortion of practically all the bones of the foot except the metatarsals and phalanges. The tarsal bones were widely separated. All of them were notably small and ill shapen. The tibia was narrower than usual and lacked the usual flare near the ankle. The epiphyseal line was present and appeared about normal. Roentgenograms of the spine showed several misshapen vertebrae at the apex of the dorsal angulation. The upper and lower vertebral epiphyses were present on one side of the vertebral bodies but missing on the narrower side. There were no fused ribs.

On August 27, 1935, a biopsy was done in two regions. The tissue removed was reported as neurofibroma. On September 26, 1935, the leg was amputated about five inches below the knee. Healing was prompt and the patient was eventually fitted with an artificial leg.

In this case the microscopic section showed a typical neurofibroma with the fibrous tissue greatly predominating. In addition there was definite evidence of endarteritis with marked web formation in one section.

Description of the Amputated Specimen

The amputated portion consisted of approximately the lower two thirds of the leg below the knee and was twenty inches long from the upper end of the amputated tibia to the tip of the great toe. The upper end of the tibia was elliptical in shape rather than triangular which is usual. The cortical bone, approximately one-sixteenth of an inch thick, was thinner than normal. The sectional muscle was much smaller in area and markedly paler than the normal muscle. The subcutaneous fat was increased in amount and presented a somewhat lobulated appearance. The skin was somewhat thicker than usual. In section the tibial nerve was noticeably enlarged, being slightly over one-half inch in diameter. The skin covering the amputated specimen showed a coarse texture,

particularly over the calf and the sole of the foot, but was less so on the anterior surface of the leg and the dorsum of the foot. This changed texture was most marked in the lower portion of the leg and below the malleoli, where it was loose, and arranged in irregular folds. The creases between the folds were from one-quarter to one-half inch in depth. Within this loose, baggy skin, which was quite moveable on the tissues beneath, the bones could be felt smaller and much more mobile than normal. The specimen was placed in formalin and dissected later. The formalin, of course, destroyed much of the hypermobility of the skin and the joints. At the time of dissection the tibial nerve was removed for examination. The portion removed was seventeen and one-half inches long, and markedly enlarged. A number of nodules which were fusiform enlargements of various fasciculi within the nerve, could be felt throughout its course, but none of them were separate from the nerve, which continued on beyond the enlargement. The subcutaneous region in the lower portion of the specimen was tough and fibrous, and gave the impression of being oedematous, though of the brawny type. The ligaments were lax and poorly developed, but not grossly abnormal. The bones of the foot were very small and extremely misshapen, corresponding to their roentgenographic appearance. They were so very soft that they could be compressed between the thumb and finger. The cortex was thin and easily cut with a knife. Within there was very little of the usual cancellous structure, but there were frequent cystic areas which did not have bony walls nor any apparent reaction in the bone surrounding them, and were filled with a thin fatty material. They seemed to be areas of exaggerated bone atrophy rather than a reaction to irritation.

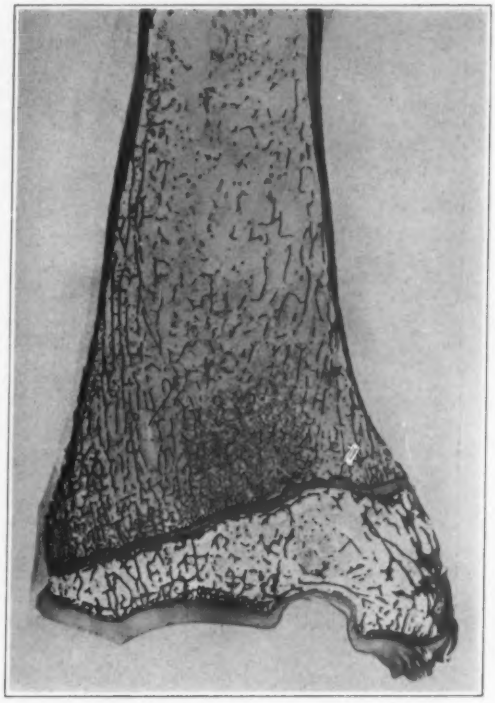

FIG. 15

Case 4. L. McC. Very low-power photomicrograph of section of the lower tibia. Note the preponderance of longitudinal trabeculae except immediately above the epiphyseal line. There was very little evidence of either osteoblastic or osteoclastic activity in the section. The epiphyseal line is narrowed and irregular in outline just above the defect in the articular surface. Note also the irregularity of ossification of the epiphysis between these two points.

The last report in this case was from his teacher who stated that his mental condition, which was "queer" in the Hospital, was rapidly becoming worse, and that he was unable to remain with normal children in school.

COMMENT ON HYPERTROPHY CASES

These four proven cases of neurofibromatosis all present one common feature—localized hypertrophy—in addition to the cardinal signs of skin pigmentation and plexiform tumor. Cases 2, 3, and 4 form a progression in the degree of deformity, which began before three years of age,—normally a period of rapid growth. Enough cases of localized hyper-

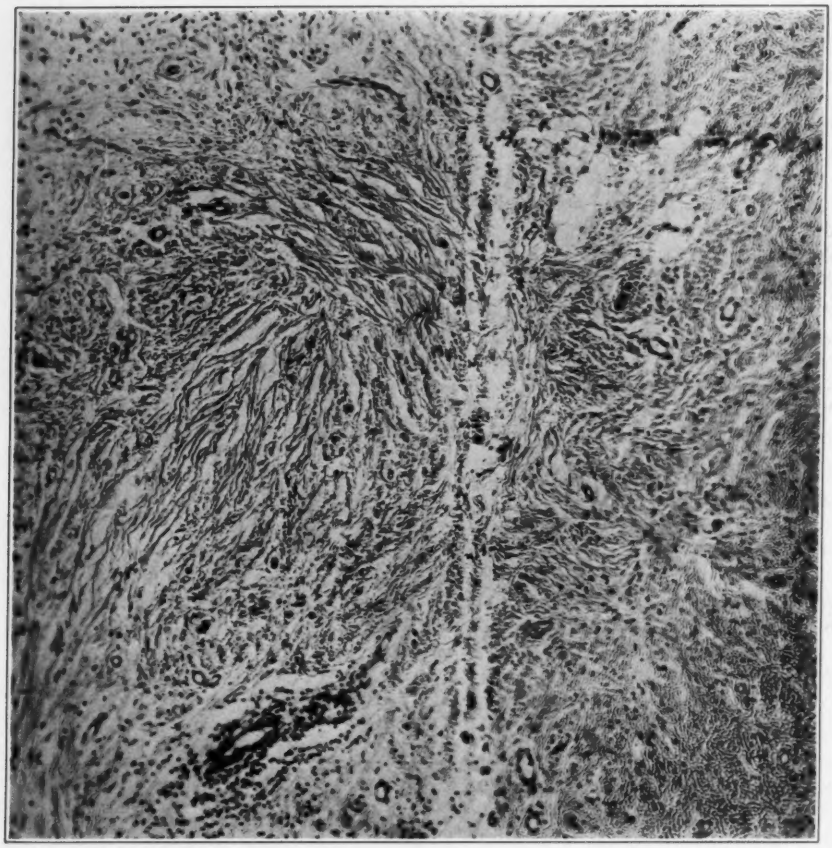

FIG. 16

Case 4. L. McC. Low-power photomicrograph of section from plexiform tumor of posterior tibial nerve showing tangled mass of fibrous tissue of mature type. In this case there is very little orderly arrangement of the fibroblasts though in certain areas there is some tendency to parallelism. Note the thickness of the walls of the arteries.

trophy associated with neurofibromatosis have been reported to make it seem more than a coincidence. However, the strongest point in favor of the theory that the neurofibroma is the cause of the overgrowth is the fact that there is a definite segmental relationship between the affected nerve and the overgrowth. Brooks and Lehman go so far as to say that there is no other cause for rapid localized overgrowth than neurofibromatosis. They ascribe the overgrowth to stimulation by actual invasion of the bone by neurofibroma. To quote them briefly, "If the tumor . . . involves the substance of the shaft of the bone and particularly if the growth of the neurofibroma is associated with a hyperplastic change in the lymphatics, then the entire bone is rendered more porous and plastic . . . this results in a growth in length of the bone, which is distributed throughout the entire bone instead of being confined to the region of the epiphyseal cartilages, and an abnormally long bone results." We find it difficult to

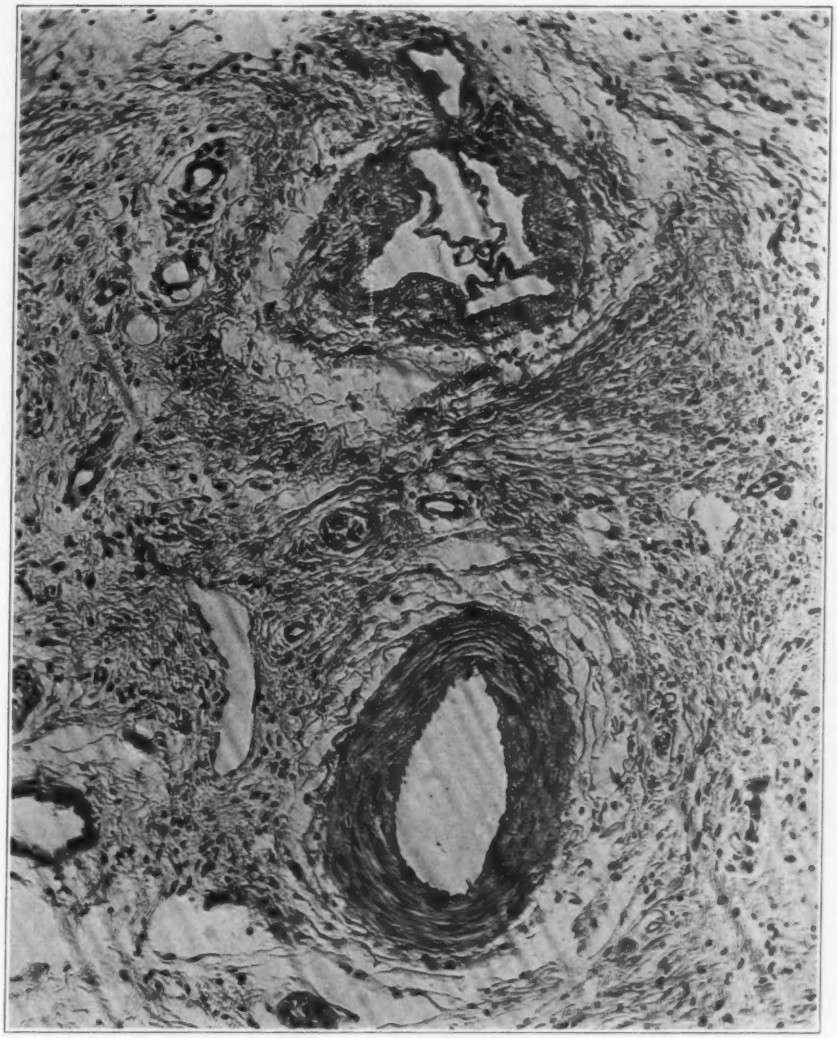

FIG. 17

Case 4. L. McC. High-power photomicrograph of two small arteries within the fibrous tissue. Note the thickened walls of both. In the lumen of the one at the top is seen a weblike endothelial hyperplasia. The lumen is irregular in shape. This is a definite endarteritis.

accept the theory that the bone grows throughout its length since it runs so directly counter to all recent work on the growth of bone. Furthermore we can find no report of actual invasion of the shaft by the neurofibroma. The tibia in Case 4 was sectioned with this very point in mind and no evidence of it could be found.

There is also a school of thought which ascribes the overgrowth to endocrinological changes. Granting that the anterior pituitary does control bone growth, it is difficult to see how a hormone which by its very

nature must have equal access to all parts of the body can cause the sharply localized overgrowth we have noted. We believe that overgrowth takes place at the epiphyseal line as in normal bone, but at a greatly accelerated rate.

Harris in his study of bone growth states that in rapidly growing bone the longitudinal trabeculae are laid down before the transverse. In the roentgenogram of the tibia in Case 4 this condition is quite distinct. It is also shown in a longitudinal section cut from the lower end of the tibia. There is, too, a notable absence of the lines of cessation of growth as described by the same author. The same condition is shown in the roentgenograms of the other two cases, but to a lesser degree. This we believe to be evidence of abnormally rapid growth from the ends of the bone. It would be easy and obvious to assume a stimulation of growth activity, but another fact must be taken into consideration. We pointed out that the tarsal bones in all three of these cases were small and misshapen in varying degrees, that is, there was in these cases not pure overgrowth, but a mixture of over and underdevelopment. The scoliosis in Case 4 seems to show the same condition, since on the wider side of the vertebral body the epiphyses are present, while on the narrower side they are not seen. We believe this is an evidence of growth distortion rather than a crushing of the vertebral body from softening. We believe that these findings (mixed over and under development) indicate, not stimulation, but rather faulty control of growth.

FIG. 18

Case 5. D. G. August 30, 1929. Photograph on admission shows the anterior bowing of the right lower leg, distinct pigmented areas over the lower spine, one faint area between the inferior angle of the right scapula and the spine, and two faint areas above the right external malleolus.

In the growth of the bones there are two factors,—one the impulse to grow, and the other the limitation and direction of the growth so that a normal pattern is attained. Does the nervous system exert this control? Certainly in these cases there is a defective pattern of growth associated with a defective nerve. The arterial changes may be of significance in this connection. Possibly the autonomic nervous system, which controls the arteries, may also have some control over growth. It may be a collaborator with the endocrine system in this.

The facts as we see them are these:

1. Localized hypertrophy is often enough associated with neurofibromatosis in a segmental relationship to warrant a belief that there is a causal relationship of the nerve lesion to the hypertrophy.

2. The hypertrophy is not pure overgrowth, but is mixed over and underdevelopment, and we believe represents uncontrolled growth rather than stimulation of growth.

3. The findings of definite evidence of endarteritis in two of these

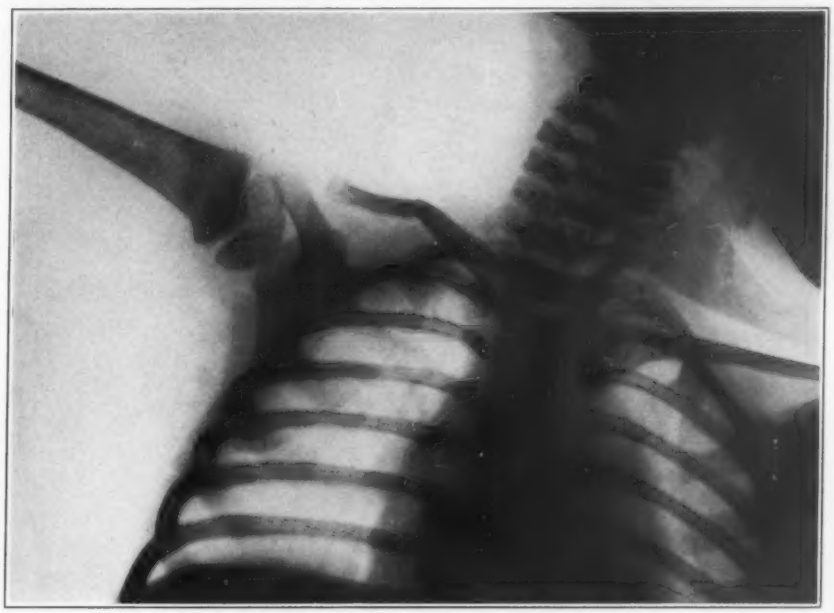

FIG. 19-A

Case 5. D. G. Roentgenogram taken April 2, 1930, shows fracture of the right clavicle. This was a complete fracture, not a "greenstick".

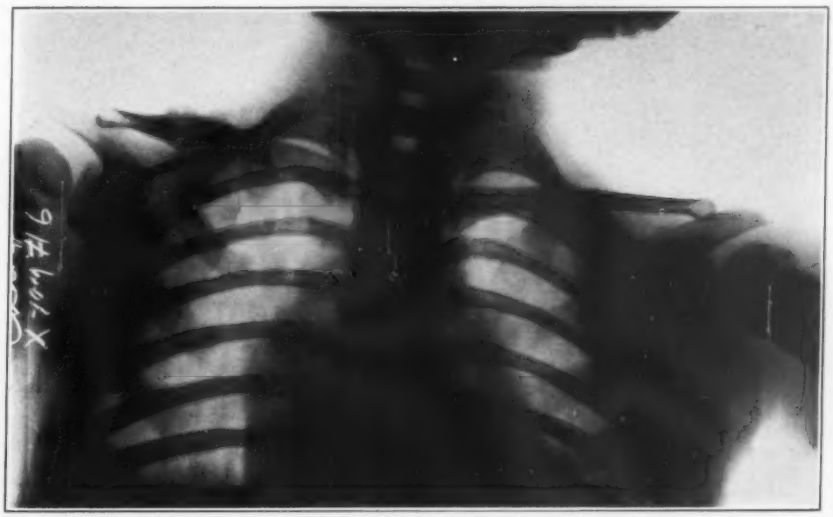

FIG. 19-B

Roentgenogram taken April 29, 1930. The callus had formed well and union was firm in three weeks. The tibia was still ununited.

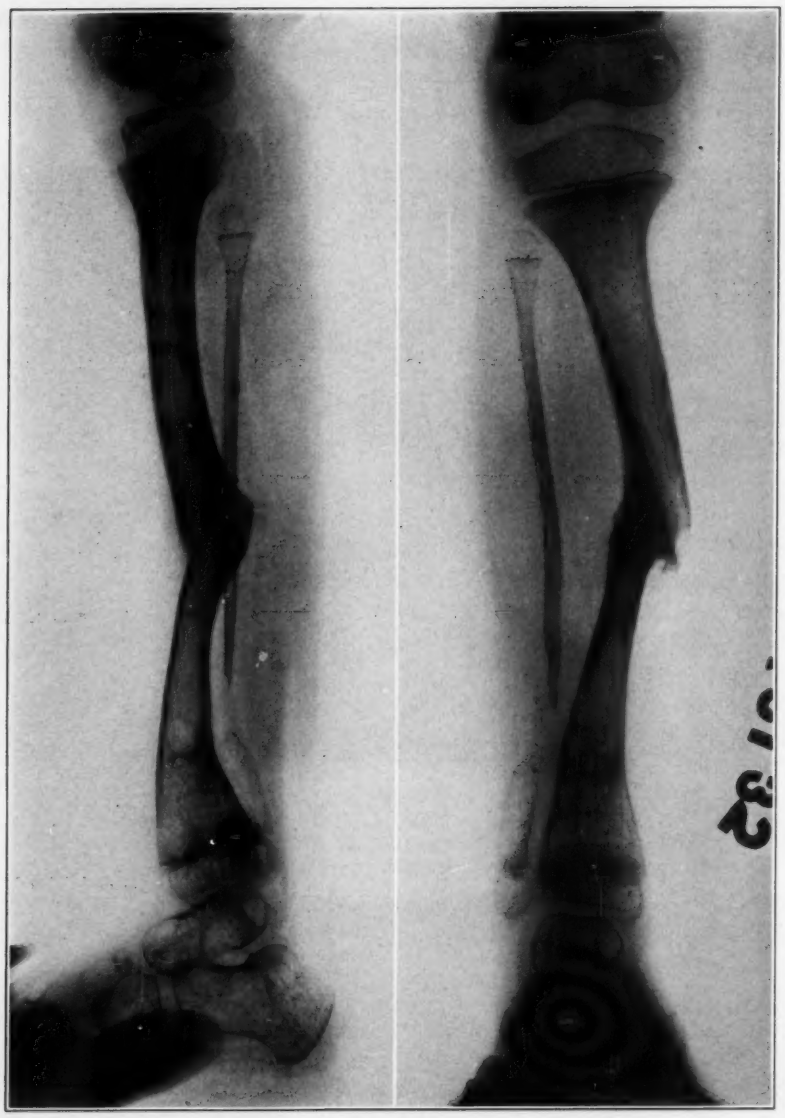

FIG. 20-A FIG. 20-B

Case 5. D. G. Roentgenograms taken June 1, 1932, almost three years after operation, show lateral and anteroposterior views of right leg. Union in malposition has finally taken place. The fibula has atrophied and there is no attempt at union. The union of the tibia does not appear any too solid as the medullary cavity of the lower fragment has narrowed and sealed over. The medullary canal of the upper fragment is open, but not in contact with the lower fragment. Near the upper and lower ends of the diaphysis are seen several transverse dark lines described by Harris as caused by temporary cessation of growth. We have considered that they may be due to cod-liver-oil administration at intervals.

Note especially the heavier dark line across the tibia above these finer lines. It is heavier and in the lateral view is triangular in outline. The posterior cortex shows a slight angulation at its base.

cases, and hints of it in the other two, may, we believe, have a bearing on the question of the control of normal bone growth.

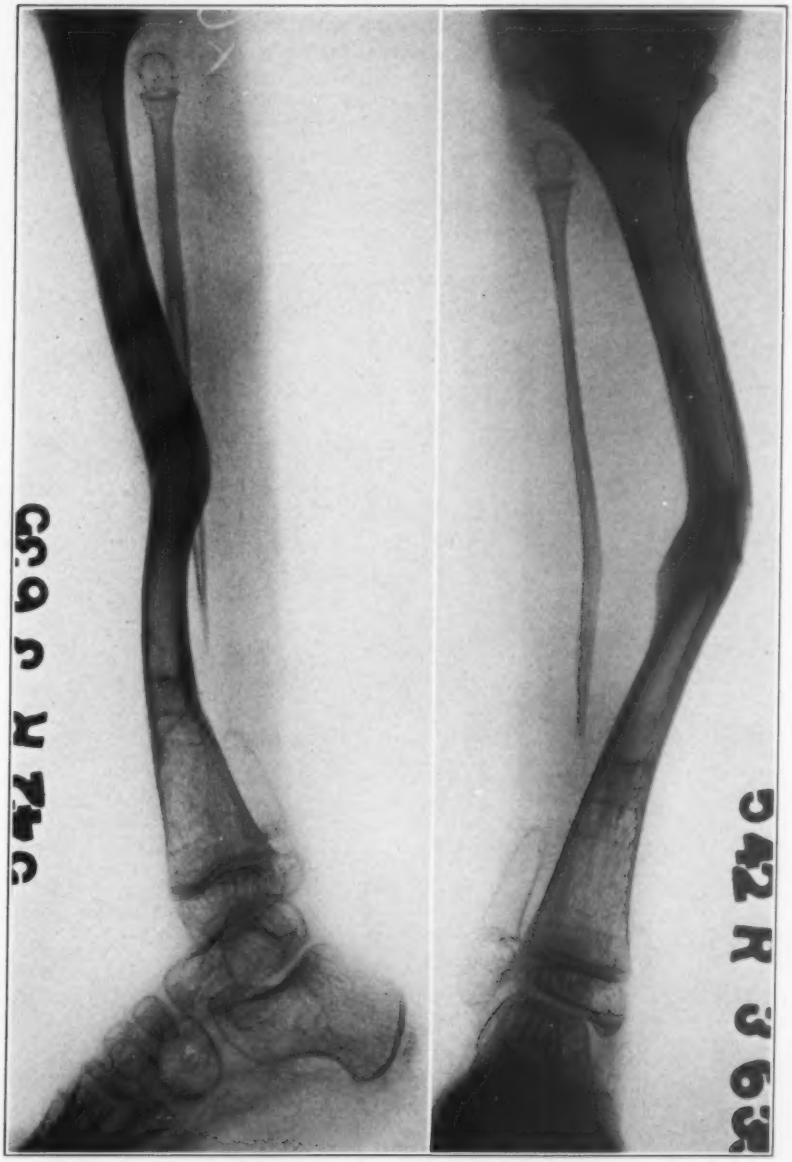

FIG. 21-A FIG. 21-B

Case 5. D. G. Roentgenograms of lateral and anteroposterior views taken March 6, 1935. Union is present though the fracture had recurred in 1933. The angulation has rounded off and the medullary canal is showing signs of opening up through the callus. There are a few lines of cessation of growth near the lower end of the diaphysis. The heavier dark line to which attention was called in Figures 20-A and 20-B is still present, though at a relatively higher level. The epiphyseal line has advanced away from it, leaving it higher in the shaft. The slight angulation in the posterior cortex is still present.

PSEUDARTHROSIS

CASE 5. D. G. was first seen at Shriners' Hospital, March 9, 1929, when she was fourteen months old.

The complaint was that her right leg was bowed.

She was born normally at full term, breast fed for nine weeks, and then put on a

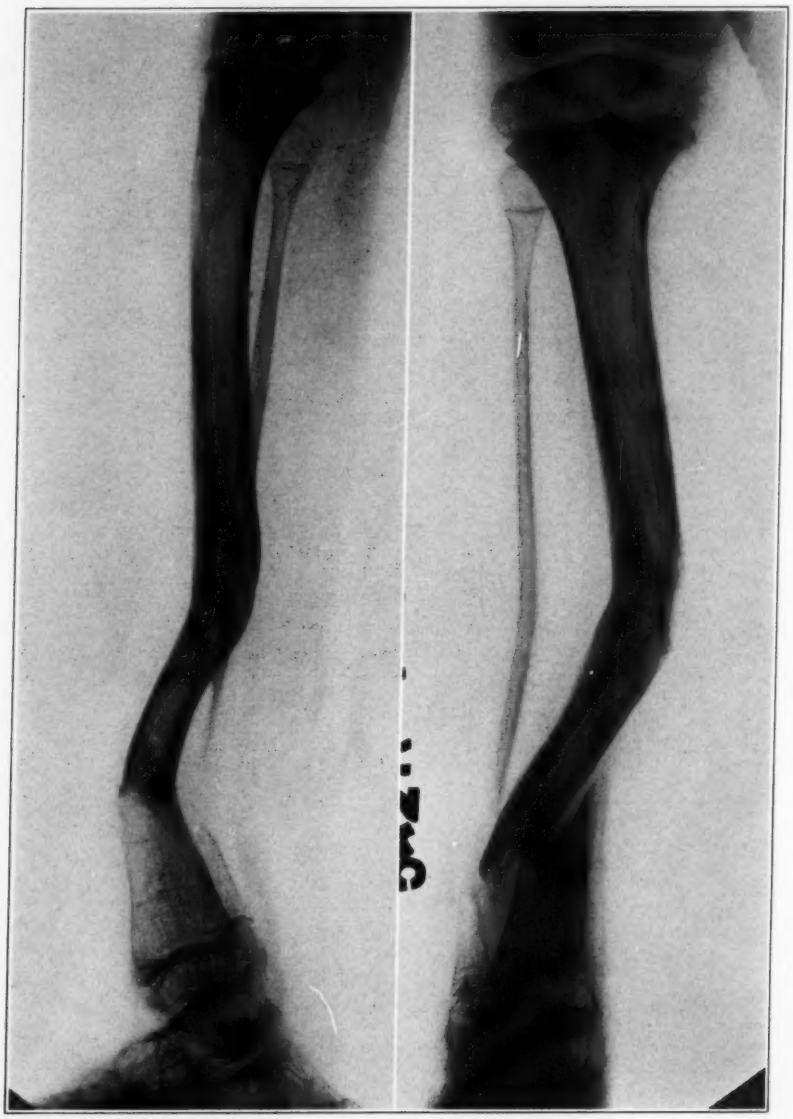

FIG. 22-A FIG. 22-B

Case 5. D. G. Roentgenograms of lateral and anteroposterior views taken January 15, 1936. The medullary canal has finally formed somewhat irregularly through the callus. There is a fresh fracture at the junction of the lower and middle thirds of the tibia at the site of the dark line to which attention was called in the two previous plates. This was apparently a danger signal a little over two years before the actual break.

formula. She had cod-liver oil and orange juice regularly. At ten months she began to pull herself up and walk, holding the sides of the crib, but stopped this shortly because she hurt her leg. She soon began to creep and kept this up until she was twelve months old, when she resumed walking. Her mother then noticed that her right leg began to curve above the ankle. Pigmentation was not noted on the first visit. Later when it was observed, her mother stated that she and the father did not have it, but an aunt did have

FIG. 23-A FIG. 23-B

Case 5. D. G. Roentgenograms of anteroposterior and lateral views taken September 23, 1940, show a complete non-union with slight attempt at callus formation at the site of the fracture shown in Figures 22-A and 22-B. The upper part of the tibia has straightened and shows very little evidence of the original non-union.

von Recklinghausen's disease (diagnosed at Mayo Clinic). Also, one of her own sisters has a child with pigmentation similar to that of the patient, but with no bone complication.

On examination, the leg showed rather marked outward and forward bowing of the tibia about three inches above the ankle joint. It was noted that it felt almost like an old fracture. There were no marked signs of rickets. She walked well and the legs were of equal length.

The roentgenograms taken at that time "showed a marked angular curve about two inches above the ankle joint. Judging from the sharpness of part of the curve this represents an old fracture rather than a rachitic deformity." We were suspicious of the deformity, and she was not admitted at the time. Later it was decided that the deformity was due to an old fracture, and, if it had healed once, it should heal again. This has proved very poor reasoning.

On September 12, 1929, an osteotomy was done and a cast applied. On March 30, 1930, she fell and fractured her right clavicle. This fracture healed easily and normally in less than a month but the tibia did not unite until eighteen months after the osteotomy. When it did heal, an inward curve developed at the site of the osteotomy. The leg was fractured again in December 1933, but healed in about six months. In September 1935, she developed puerpura hemorrhagica and was treated in the Medical Department at Northwestern University Medical School. On October 16, 1935, she fell and fractured the leg again about two inches below the original non-union. This last fracture has not yet united, though a bone graft was done on July 28, 1938.

CASE 6. R. R. was first seen at Shriners' Hospital, September 20, 1929, when she was six years of age.

Birth and development were normal until she was eight months of age, when she

FIG. 24-A

FIG. 24-B

Case 5. D. G. Photographs taken January 17, 1940.

Fig. 24-A: Back view shows the pigmented area near the base of the spine which has persisted since the first picture. There is a group of pigmented spots between the scapula which are much smaller and resemble freckles though considerably larger.

Fig. 24-B: Front view shows the same pigmented area on the upper right arm. This area is near the edge of a large irregular area of light pigmentation.

fell off the bed and hurt her left leg. It was considered a sprain for three weeks, at which time a roentgenogram showed a fracture of both bones in the lower third of the leg. A cast was applied for two months. No union resulted and an open operation was done, also without union. She has worn a cast or brace ever since without any union. She can walk with the support but not without it. The mother has Von Recklinghausen's disease of the fibroma molluscum type.

Examination showed mobility at the junction of the lower and middle thirds of the left leg. All four ends of the fragments could be palpated. The left leg was approximately seven centimeters shorter than the right. There were several definite elliptical areas of brownish pigmentation on the body, arms, and legs.

The roentgenogram showed "a complete ununited fracture of both bones about three inches above the astragalotibial joint. The fragments were all sharply pointed. There was moderate atrophy of all the bones of the foot and leg."

Four operations including a transplant of heterogeneous bone and an onlay graft from the normal fibula were done between 1929 and 1936, all without union. On May 5, 1936, the leg was amputated about five inches below the knee and an artificial leg eventually fitted. At the time of the operation the nerves of the amputated portion were inspected. The posterior tibial nerve appeared somewhat larger than normal, but did not feel nodular, nor were the fibers convoluted. However, a later microscopic examination revealed a very interesting type of neurofibroma in which there was a marked increase of the fibrous tissue in the nerve bundles, but in only a few of them had the fibrous tissue entirely displaced the nerve tissue. Yet in these there was seen the typical structure of a neurofibroma. The nerve was sectioned at different levels and the appearance varied as shown in the photomicrographs. Even in the specimen in which the neurofibromatous changes seem relatively mild there is evidence of the endarteritis noted in the previous cases.

FIG. 25

Case 6. R. R. Photograph taken on admission in 1929 shows marked shortening and deformity of the lower left leg. Several pigmented areas are shown. There is one prominent one on the abdomen, also fainter ones below the left elbow, below the axilla, and at the ankle. The pigmentation at the knees is discoloration from creeping.

CASE 7. E. B., aged two and one-half years, was admitted to Shriners' Hospital, March 22, 1935, with the complaint of deformity of the left leg near the ankle, and motion at the point of deformity. The mother stated that the leg had been the same way ever since he was born, but she did not know whether it was broken at the time of delivery or not. She said he did not seem to have any pain. He has been learning to walk recently, the bowing has been increasing, and the leg becoming shorter. The mother had numerous molluscous tumors on her face and arms. The child had several rather indistinct areas of light brownish pigmentation on the skin of his chest, though on recent examination these could not be found. We feel, however, that the association of maternal affliction and the bone condition warrant the assumption of neurofibromatosis.

On examination, the left tibia showed a marked anterior curve in the lower third. The apex of the curve was also a point of motion, and a little crepitus could be felt occasionally but not constantly. There was no evidence of pain on any reasonable amount of motion.

The roentgenographic report stated "there is a complete fracture of both bones in

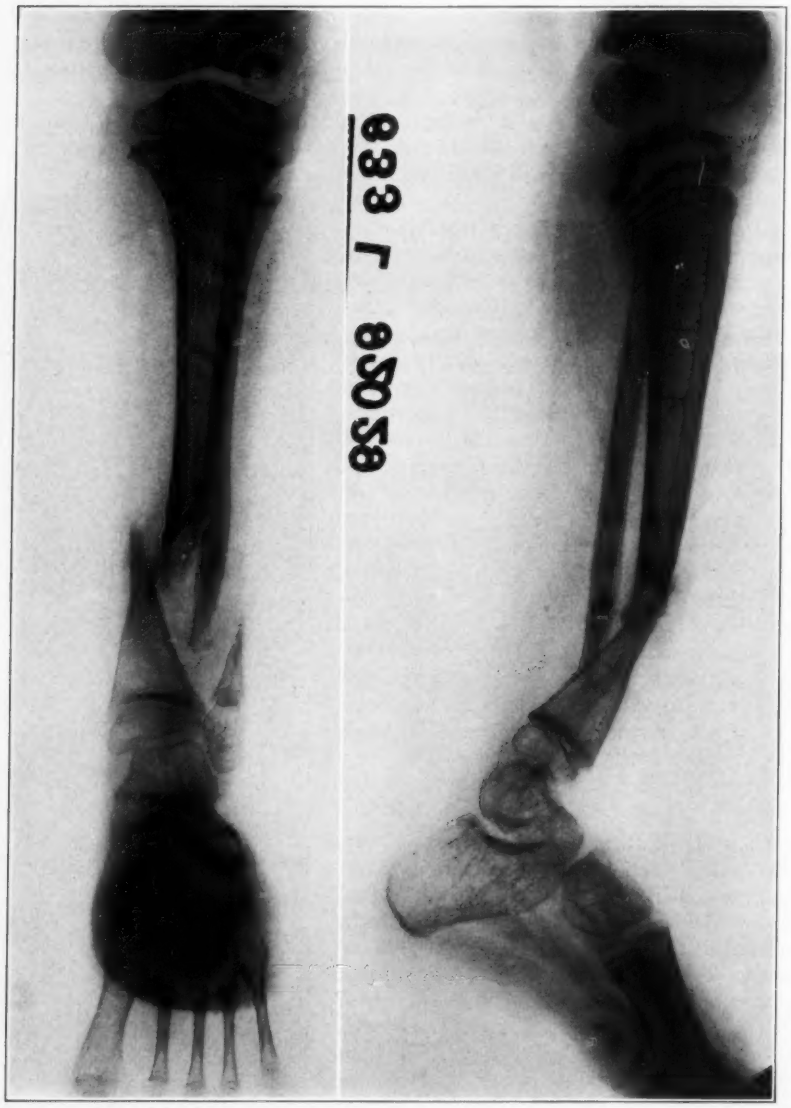

FIG. 26-A FIG. 26-B

Case 6. R. R. Roentgenograms of anteroposterior and lateral views of the left leg taken on admission September 20, 1929, show complete non-union of both bones. All the fragments have the typical sharp points of pseudarthrosis. There is a slight periosteal reaction at the tips of the upper fragments. The tibia shows several transverse dark lines near the upper end of the diaphysis. The atrophy of the bones is moderate. There is a typical "cod-liver-oil" line at each epiphyseal line.

the lower third and an equally complete non-union. The fragments are all very sharp pointed."

Only one operation has been done and it was completely unsuccessful. The child walks in supportive apparatus. Remembering Henderson's observation that there is a better chance of success by operative measures at the time of adolescence, we are hoping to keep the bone in good condition by use until that time.

FIG. 27-A FIG. 27-B

Case 6. R. R. Roentgenograms of lateral and anteroposterior views taken August 13, 1930, ten months after the first operation, show considerable periosteal reaction and bone production on the *upper* fragment. The lower fragment has the usual conical shape, and there is absolutely no union. There are several transverse dark lines near the upper epiphyseal line, and one near the middle of the shaft.

DISCUSSION OF PSEUDARTHROSIS CASES

In this group of cases the bone lesion is of an entirely different type from the group of hypertrophies, yet there are similarities. All but one showed the typical pigmentation. There was a definite segmental relationship between the bone lesion and the neurofibroma in the one case we have been able to study histologically. This segmental relation-

FIG. 28-A FIG. 28-B

Case 6. R. R. Roentgenograms of anteroposterior and lateral views taken June 3, 1931, six months after the third operation (heterogeneous bone graft). There has been considerable bone production at the lower end of the upper fragment. The lower fragment is now squared at the end, and there is end-to-end apposition, but no union. The bone appears to be of fairly good quality.

ship is hinted at in the normal healing of the fractured clavicle in Case 5 as compared with the non-union of the tibia.

In the discussion of the previous group of cases we expressed our

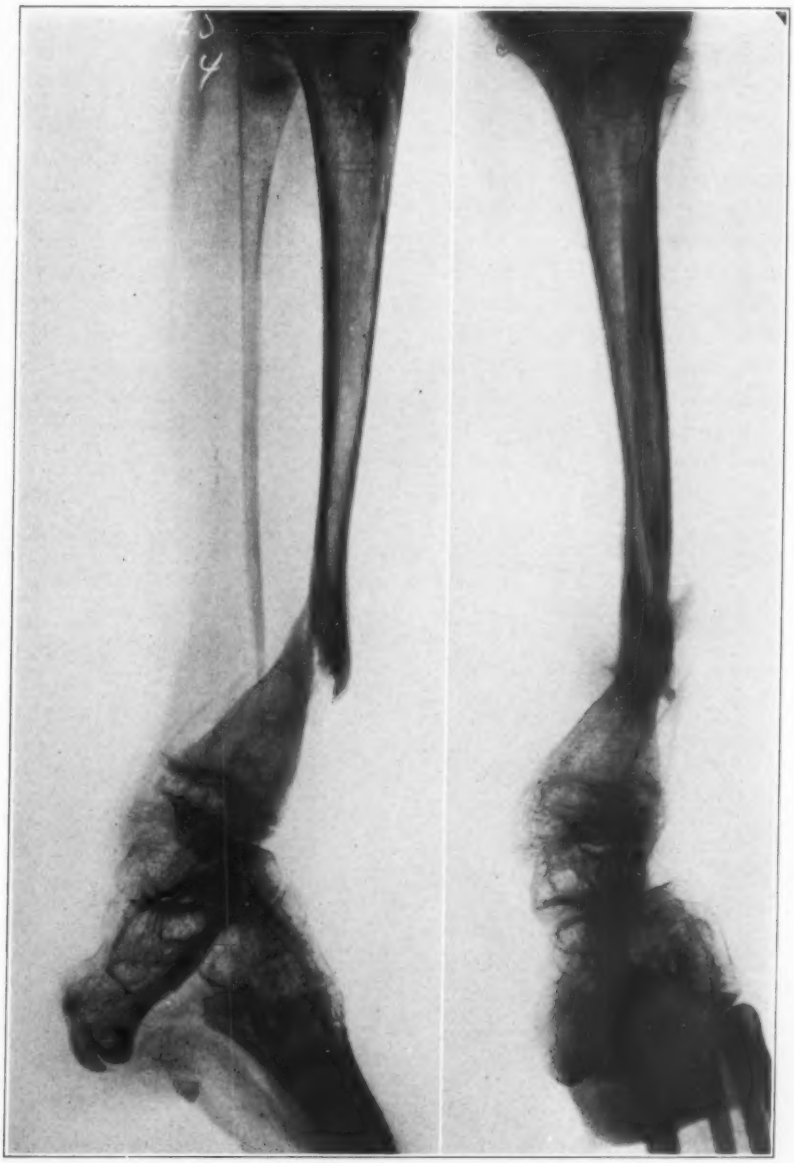

FIG. 29-A FIG. 29-B

Case 6. R. R. Roentgenograms of lateral and anteroposterior views taken December 4, 1935. The bone fragments have now become sharp-pointed again, and the shaft is much narrowed. The bones of the foot are becoming distorted. This deformity we ascribed to the fact that for about ten years she had been wearing some form of supportive apparatus,—usually a cast with an extension bar.

opinion that the deformities present were the result of uncontrolled growth rather than stimulated growth. In these pseudarthrosis cases the roentgenographic evidence indicates that the growth of the affected bone is at about the normal rate. The bone grows, but it does not unite. Now if we consider the uniting of a fracture as a function of bone growth (using the term "function" in a mathematical rather than an anatomical sense), there is a disturbance of growth in these cases. These bones lack some power of forming union, which is a function of normal bone. The process of union in a fracture is a complicated process, in fact, it can hardly be called a process but is rather a series of processes, some of which are generally known and some of which are not nearly so well known. Yet in the normal healing of a fracture these processes follow a definite pattern and the result is an orderly development and restoration of bone structure. However, in these pseudarthroses the pattern of restoration is not followed, so it seems evident that somewhere in the line there is a lack of control of some part of the process. Since pathological nerves are found in relation to the pathological bone, it seems fair to assume that the two are related. We know that the physiologist mentions "trophic nerves" only to scoff at them, but we also know that nerve injury or defect does produce trophic changes in many parts of the body. Whether

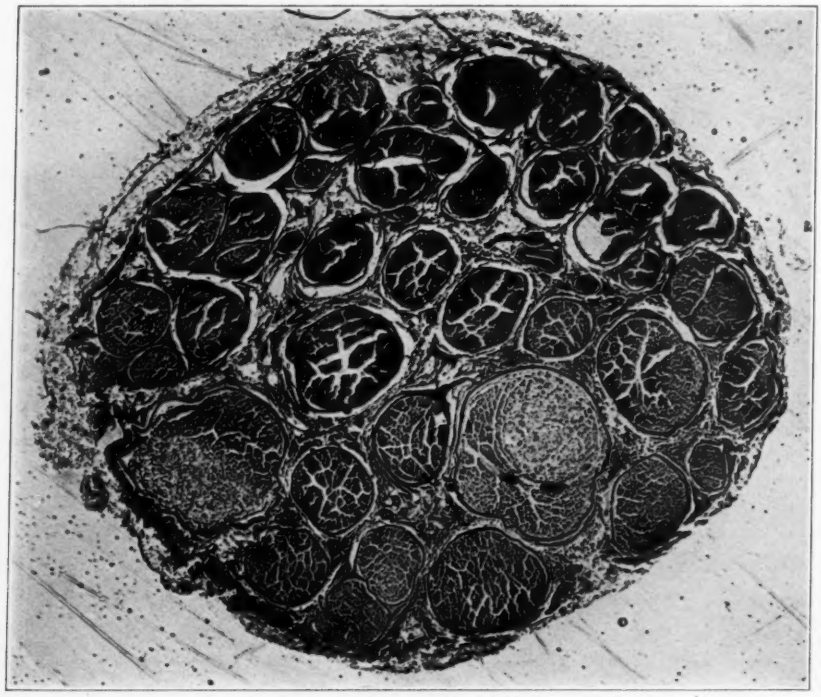

FIG. 30

Case 6. R. R. Low-power photomicrograph of the posterior tibial nerve,—a general view, showing two fasciculi markedly pathological and the upper half of the entire nerve showing mild fibrous infiltration.

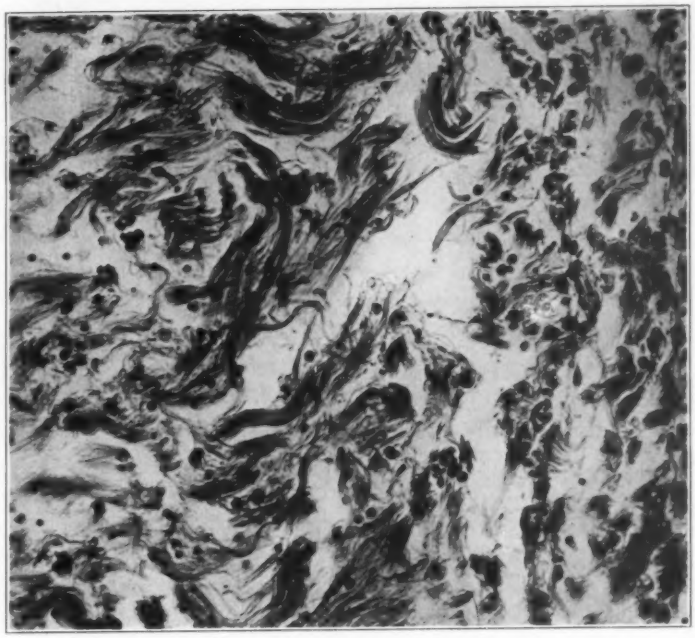

FIG. 32

Case 6. R. R. High-power photomicrograph of the same area as shown in Figure 31 shows details of fibrous infiltration. The fibrous tissue is apparently endoneural. The irregular dark spots are probably "gitter cells" with ingested degenerated myelin.

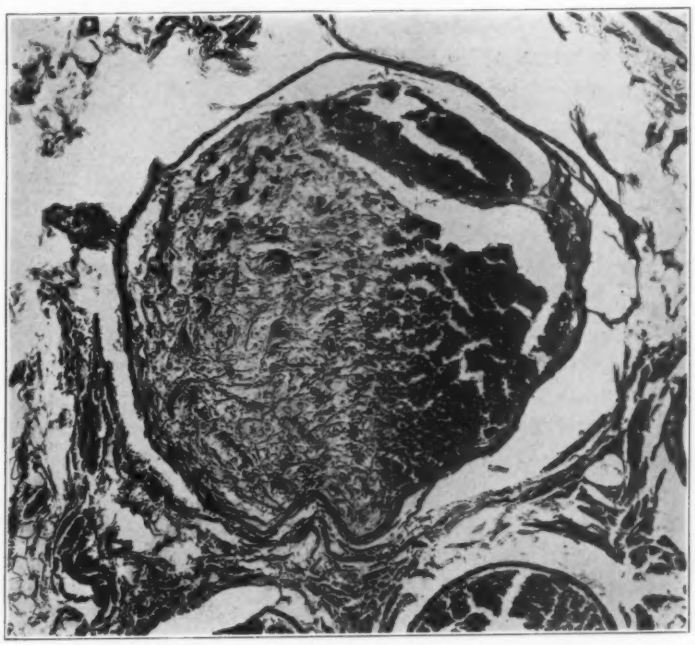

FIG. 31

Case 6. R. R. Medium-power enlargement of fasciculus seen in the upper right quadrant of the first section (Fig. 30), showing background of reticulated tissue from which nerve fibers have almost disappeared.

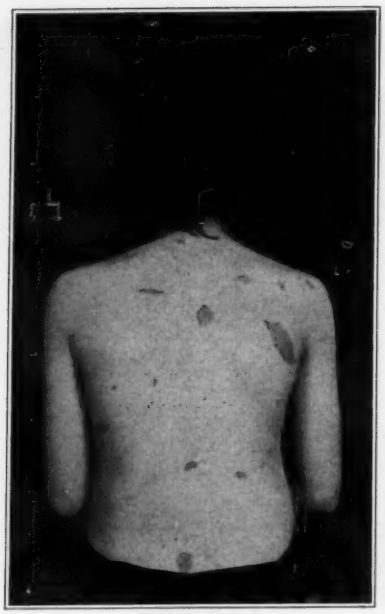

FIG. 33-A

FIG. 33-B

Case 6. R. R. Photographs taken January 17, 1940, showing the pigmented areas. The face also shows pigmentation which was present from the beginning.

the nerve injury is the immediate cause or whether it acts through a series of mechanisms, it still has an effect on the processes of the part affected. We believe, therefore, that the condition of the nerve and the pseudarthrosis stand in the relation of cause and effect, though the mechanism of the production is not entirely clear.

SUMMARY AND CONCLUSIONS

We have considered two very diverse orthopaedic conditions, both of which are associated with neurofibromatosis. Considered superficially, these two conditions are about as much alike as black and white. As we have said previously, the neurofibroma itself is unobtrusive, and the associated pathology is the condition which attracts attention to itself, from both the patient and the medical man.

We have expressed our opinion that the bone changes we have studied in these cases are all due to lack of control of the ordinary growth processes of bone. Under this general heading of uncontrolled growth we would classify the changes found as follows:

1. Hypertrophy, or overgrowth, as illustrated in the increase in length of members.
2. Hypotrophy, or underdevelopment as illustrated in the small tarsal bones in Cases 3 and 4.
3. Distortions of growth as shown by the vertebrae in Case 4.
4. Changes in the constitution of bone as exemplified by its failure to unite after fracture.

These four changes seem to include the bone changes as we see them, both in our own cases and in others described in the literature. The changes seen in a case may fit into more than one of these classes.

We believe that these bone changes are not merely associated with, but are the result of, the changes in the nerve either directly or indirectly. The reason for this belief is the frequency of the signs of neurofibromatosis associated with the types of deformity we have studied. However, the converse that these deformities always accompany signs of neurofibromatosis does not hold good. The most convincing argument for the causal relationship is the segmental localization of the deformities. This holds good not only in our cases but in many reports in the literature. The finding of definite endarteritis, to which we have called attention, is of special interest. We believe that it is a fairly constant finding. One point of interest is the effect that such an endarteritis might have on other organs. For instance in the brain it might account for mental changes which frequently accompany neurofibromatosis. Again, if it occurs in the arteries supplying any of the ductless glands, it is quite conceivable that dysfunction might result in that particular gland and a peculiar chain of symptoms be initiated. This may account for much of the rather indefinite endocrine symptomatology. Still another point of interest in this finding of endarteritis is whether it may furnish a clue to what we have called the uncontrolled growth of parts of the body. The arteries are under the control of the autonomic nervous system. May not this system also have some control of the normal pattern of body growth? We must admit we do not have enough evidence to advance it as an hypothesis but the idea is intriguing.

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UNUNITED FRACTURE OF THE NECK OF THE FEMUR TREATED BY HIGH OBLIQUE OSTEOTOMY *

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Despite the fact that in recent years the internal fixation of new fractures of the neck of the femur has stimulated renewed interest and achieved far better results than heretofore, there still remain a large number of cases, which, because of the failure of the surgeon to make use of these methods or because of the failure of the method, go on to non-union. Because of the frequent incidence of non-union, many procedures have been advocated for its relief, most of which have proved to be a boon for these patients. These operations have been divided roughly into two groups,—those which are termed reconstruction procedures, such as the Whitman, Colonna, and Brackett operations, and those which aim to restore the anatomical and physiological relationships of the hip joint, such as the Albee bone-graft method, and the operations described by Gallie and Lewis, Dickson, Compere and Lee, Magnuson, and King.

Since all these methods have been widely employed and extensively reported, there is no need to go into detail concerning their relative merits or the individual operative procedures. However, each one of these methods involves extensive operative technique, which in many instances results in postoperative shock and hemorrhage, and good end results are dependent upon many factors of which a meticulous operative technique is of utmost importance.

In a recent article Colonna has divided ununited fractures of the neck of the femur into two groups: (1) those in which there is a viable head; and (2) those in which the head has undergone aseptic necrosis. He has stated that the reconstruction type of operation, such as he advocates, is indicated only for those individuals in whom the ununited head is not viable. It would be fair to postulate, therefore, that these indications would apply also to the other reconstruction operations, which are predicated on the principle of the removal of the ununited head and the implantation of the remaining neck or trochanter. Although there are no exact statistics available, it is safe to say that by far the larger proportion of ununited femoral heads are viable. King, in his excellent and comprehensive review of both recent and old cases, emphasized two important points. (1) A three-weeks-old fracture can be arbitrarily called old and ununited, as it can be assumed that the head of the femur, detached from its blood supply, has less chance of osseous union, and that secondary changes are more probable than if operation were performed earlier. (2) Out of fourteen ununited fractures treated within three months by extra-articular osteosynthesis with a Smith-Petersen nail, osseous union was obtained in

* Read at the Annual Meeting of the American Orthopaedic Association, in Kansas City, Missouri, on May 7, 1940.

64.3 per cent., but in almost half a severe osteo-arthritis developed. Of sixteen ununited fractures treated within two years by extra-articular osteosynthesis with a Smith-Petersen nail and whole-thickness fibular peg, osseous union was obtained in 68.75 per cent. and in nearly one-third osteo-arthritis of a moderate form developed.

In 1922 the writer had the opportunity of studying patients with ununited fracture of the femoral neck on whom an oblique osteotomy had been performed by Hass. The operative procedure appeared so simple, compared to the other popular methods, and the results so excellent that this method has been employed in all suitable cases,—namely in those individuals in whom the head of the femur was viable. This paper is a report of twenty-six patients who were operated upon.

INDICATIONS

All cases in which there had been no reduction, or in which the reduction had been unsuccessful, were considered suitable for this method if the head was demonstrated roentgenologically to be viable. Notwithstanding the fact that King designates a three-weeks-old unreduced fracture as ununited, the shortest interval between incidence of fracture and osteotomy in our series was six weeks. This method was contra-indicated in those cases in which definite aseptic necrosis or osteo-arthritis of the ununited head had developed and in those in which the patient's general physical condition was of such a serious nature as to preclude any type of surgical operation, even one as simple as the osteotomy.

Before describing the details of the operative technique, it may be well to discuss the principles on which the high oblique osteotomy is predicated. It is readily agreed that the shearing force of the fractured femoral neck on the head is the primary factor in the causation, not only of the fracture itself, but also of the deformity. This shearing force is also a very important factor in the eventual end result, regardless of what treatment is employed for the recent fracture. The first objective, therefore, in the osteotomy is to overcome this shearing force as far as possible, so that the fractured head assumes a position more or less on top of the neck instead of lateral to it. Secondly, in addition to overcoming this shearing force, the original osteotomy has been modified in such a manner that when the distal fragment is displaced inward, a portion of the head rests directly upon it, so that it acts as a direct source of weight-bearing. Moreover, the head is in direct approximation to the shaft, thus shunting off the femoral neck.

SELECTION OF ANAESTHESIA

It has been the writer's practice to perform the osteotomy under general anaesthesia and the anaesthetic of choice has been avertin, in the dosage of approximately 80 to 85 milligrams per kilogram of body weight. For most of these cases this was sufficient to carry the patient through the entire operative procedure, but in some instances it was necessary to sup-

plement it with nitrous oxide and oxygen anaesthetic or with novocain block. Where there was a contra-indication to the use of avertin either nitrous oxide and oxygen or a spinal anaesthetic was employed.

OPERATIVE TECHNIQUE

The roentgenogram is studied to determine the degree of coxa vara and consequently the relation of the neck to the ununited head. If there is a marked coxa vara due to excessive upward displacement of the greater trochanter, it may be necessary, as a preliminary procedure, to apply traction to the leg for a sufficient period to restore the relation of the neck to the head, or at least to the position it assumed immediately after the occurrence of the fracture. It is not essential to reduce completely the coxa vara before the osteotomy is performed.

Since it is necessary to immobilize the patient in a plaster-of-Paris hip spica following osteotomy, the operation must be performed on a fracture table with both feet fastened to the stirrups in slight abduction, and with moderate internal rotation of the fractured limb. Some of the shortening, if still present, should be overcome by traction exerted on the fractured limb with the aid of the fracture table before the level of the osteotomy is determined, because the osteotomy should be performed through or above the lesser trochanter.

When the relationships are found to be favorable, the osteotomy is performed as follows: A lateral incision is extended from the prominence of the greater trochanter downward for approximately three inches, similar to that employed for extra-articular osteosynthesis with the Smith-Petersen nail, and the femur is exposed. To salvage as much of the length of the femur as possible, and to implant the lesser trochanter under the femoral head, the site of the osteotomy must be accurately determined. After the upper shaft of the femur has been exposed, a Kirschner wire, Steinmann pin, or metal screw is inserted through the site and in the direction of the proposed osteotomy, and an anteroposterior roentgenogram is obtained to determine the exact level of the osteotomy (Figs. 1-B and 1-C). This position should, if at all possible, be in the intertrochanteric space so that the inner portion of the osteotomy is just above or through the lesser trochanter. By means of a sharp osteotome the osteotomy is now performed in the horizontal plane with the osteotomy pointing upward and assuming an angle of approximately 20 to 30 degrees with the shaft of the femur. When the proximal and distal fragments have been completely divided, the distal portion of the osteotomy is pushed inward approximately one-half inch, according to the method described by McMurray for the relief of arthritis deformans of the hip joint. After the distal portion has been forced inward, the thigh is then abducted to an angle of approximately 30 degrees, the amount depending upon how satisfactorily the distal fragment has been displaced inward. There is a particular advantage in performing the osteotomy above the lesser trochanter if at all possible, as McMurray has shown, because the muscle

FIG. 1-A

Roentgenogram, taken August 15, 1938, of ununited fracture of the femoral neck of one year's duration.

FIG. 1-B

Roentgenogram, taken September 3, 1938, showing Steinmann pin at the site of the proposed osteotomy to determine accurate course and level of the osteotomy.

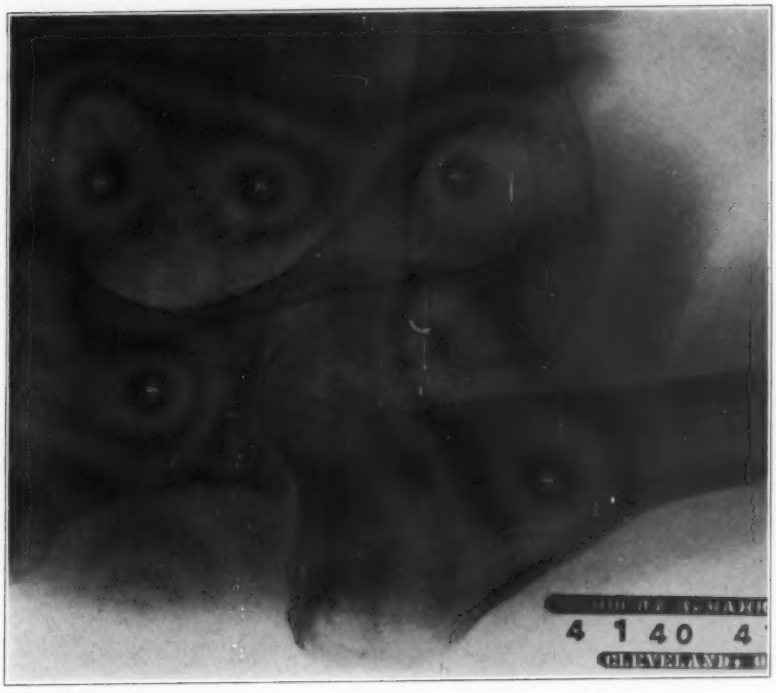

FIG. 1-D

Roentgenogram, taken April 1, 1940, showing high oblique osteotomy and union of a previously ununited femoral neck.

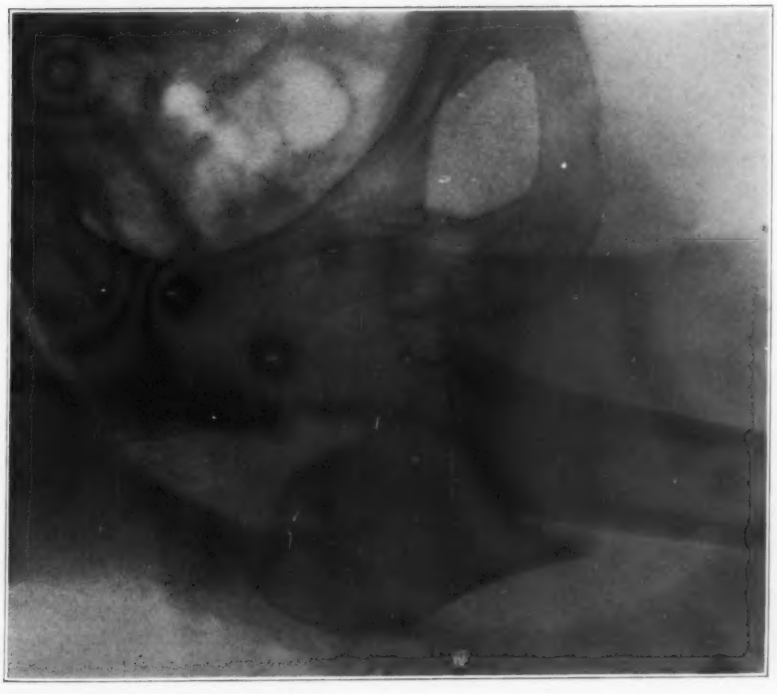

FIG. 1-C

Roentgenogram, taken September 10, 1938, of osteotomy carried through the course designated by the Steinmann pin.

attachments to the lesser trochanter assist in displacing the distal fragment inward by their pull. It is important that the osteotome divide the upper femur into two complete upper and lower fragments, without any secondary fragments being broken off. Otherwise a protruding piece of bone, either from the proximal or distal fragment, may prevent this inward displacement of the distal fragment. The wound is then closed, and a plaster-of-Paris hip spica is applied with the femur in abduction of approximately 30 degrees and with the hip and knee in slight flexion. It is important to accomplish this abduction with the requisite pressure exerted on the thigh, and not on the knee or the leg below the knee.

The osteotomy is checked by roentgenograms a few days after the operation to ascertain its position, and, if unsatisfactory, remanipulation is carried out. Six weeks after the osteotomy another roentgenogram is obtained, this time to determine the degree of callus formation. In a preponderance of the author's cases there was sufficient callus demonstrable after this period to permit removal of the hip spica. If the roentgenogram does not demonstrate adequate callus formation, the osteotomy is rechecked in two weeks, and almost invariably there is sufficient healing at this time to permit the removal of the external fixation.

The patient is now immediately allowed up on crutches, and is encouraged to bear weight. Whatever residual shortening there may be is compensated for by an elevation of the heel and the sole. As soon as feasible, the patient is referred for physiotherapy, and he receives massage, muscle training, and active motion, with gradually increasing passive manipulation of the hip and if necessary also of the knee. The crutches, and the cane which is employed thereafter, are both discarded as soon as possible.

In determining the end results of the high oblique osteotomy in patients on whom it has been performed, the following factors have to be considered:

1. Hip function, which should include sufficient range of motion in the hip joint to permit the patient to dress and, particularly, to put on his shoe and stocking.
2. Knee function, which contributes to good hip function.
3. The degree of shortening.
4. The amount of residual pain and discomfort.
5. Union of the ununited fracture, which is necessary for optimum function.
6. The degree of postoperative shock.
7. The incidence of infection.

DISCUSSION

In the series of twenty-six patients operated upon, the ratio of females to males was two to one. The ages ranged from fifty-seven to seventy-nine years. The greatest period of non-union was two and one-half years, and the shortest six weeks. One patient we were unable to locate to

FIG. 2-B

Roentgenogram, taken August 3, 1939, showing reduced coxa vara and high oblique osteotomy.

FIG. 2-A

Roentgenogram, taken May 30, 1939, of ununited fracture with coxa vara following Smith-Petersen nailing.

evaluate the end result. There was only one death, which occurred three weeks after the osteotomy, from a cerebral complication in a seventy-three-year-old female patient, with Parkinson's disease. The high oblique osteotomy was considered to have failed in three of the twenty-five patients. In one patient there appeared to be an increase in the original non-union of the neck in spite of the fact that the osteotomy had healed in a satisfactory position. This failure may have been due to the fact that the osteotomy was too high and actually displaced the head too far upward. In another patient, a male with Parkinson's disease, there are considerable restriction of motion, complaint of pain, and difficulty in locomotion, partly due to the patient's illness. Of the twenty-two remaining cases, it is interesting to note that the earlier these patients were operated upon following the original fracture, the more rapid was the convalescence, and the greater the restoration of function of the hip and the knee. All have resumed their former gainful occupations and are able to get about with very little difficulty or discomfort. In none of these patients to date

FIG. 3-A

Roentgenogram, taken July 26, 1939, of ununited fracture of the neck of the femur of two-and-one-half years' duration.

FIG. 3-C

Roentgenogram, taken December 26, 1939, showing union of osteotomy and previously ununited femoral neck.

FIG. 3-B

Roentgenogram, taken October 13, 1939, showing high oblique osteotomy and reduced degree of coxa vara. Compare with Fig. 3-A.

FIG. 4-A

Roentgenogram, taken April 23, 1938, showing apparent union of fractured femoral neck six months after injury.

FIG. 4-B

Roentgenogram, taken October 27, 1938, showing definite nonunion with coxa vara one year after injury.

FIG. 4-D

Roentgenogram, taken March 21, 1939, showing union of the osteotomy and the neck.

FIG. 4-C

Roentgenogram, taken February 10, 1939, of high oblique osteotomy, showing the head implanted directly on the top of the lesser trochanter, thus completely overcoming shearing force.

FIG. 5-A

Roentgenogram, taken August 26, 1938, of anteroposterior view of ununited fracture of the femoral neck with coxa vara.

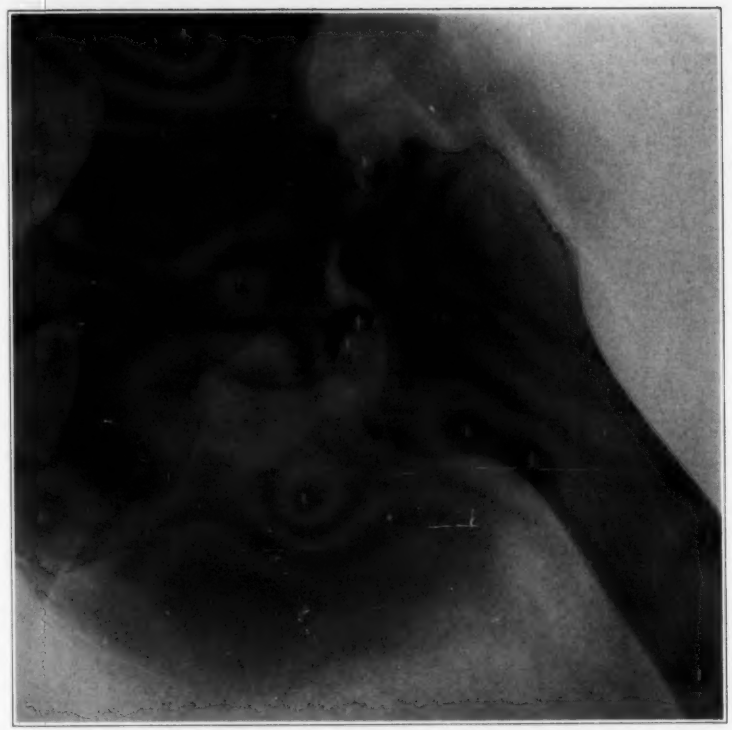

FIG. 5-B

Roentgenogram, taken December 12, 1938, of semilateral view indicating non-union.

FIG. 5-D

Roentgenogram, taken June 12, 1939, showing healed osteotomy and femoral neck with head directly on top of the lesser trochanter.

FIG. 5-C

Roentgenogram, taken January 16, 1939, of high oblique osteotomy, showing the lesser trochanter under the head of the femur.

FIG. 6-B

Roentgenogram, taken April 6, 1940, of high oblique osteotomy, showing coxa vara completely corrected with lesser trochanter directly under the head.

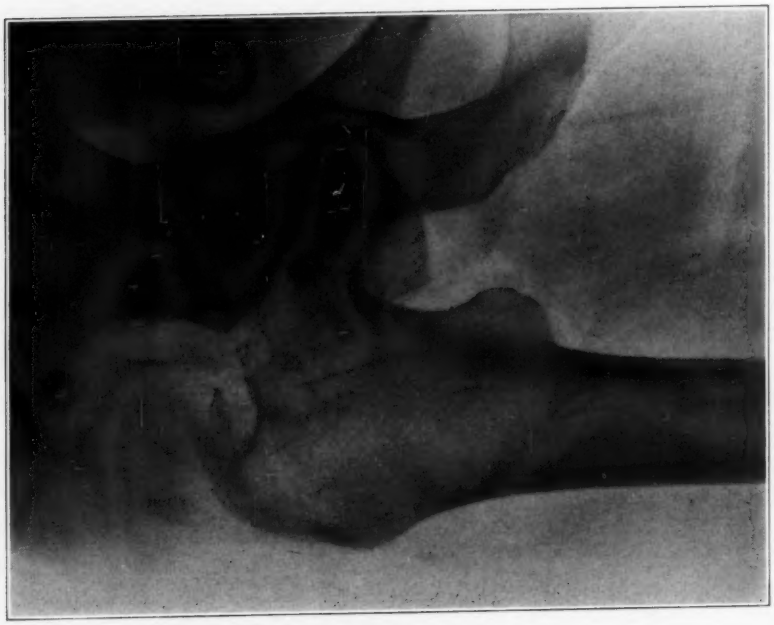

FIG. 6-A

Roentgenogram, taken January 16, 1940, showing fracture of the neck of the femur with coxa vara of six weeks' duration.

FIG. 6-C

Roentgenogram, taken August 17, 1940, showing union of osteotomy and femoral neck with the head and trochanters in excellent relation to the shaft.

has there been any evidence of secondary osteo-arthritis or aseptic necrosis.

Hip Function. All but one of the twenty-two patients had at least 75 degrees of flexion of the hip; this one had 60 degrees. The greatest amount of flexion was 110 degrees. In each of these individuals there was approximately 45 degrees of external and internal rotation of the thigh. Abduction averaged approximately 20 to 45 degrees, and adduction averaged 30 degrees.

Knee Function. The longer the period of time that had elapsed between the original fracture and the osteotomy, the greater the restriction of motion in the knee. In many of these patients, there was marked restriction of motion before the osteotomy was performed. However, in each of these individuals knee function has been restored to a great extent, and, with the aid of well-planned and properly directed physiotherapy, in many instances it has been restored completely.

Shortening. It is the opinion of some of the observers that leg length is sacrificed and consequently shortening is increased following a high oblique osteotomy. In the writer's experience this has not been the case. When the osteotomy is performed at the desired level, the ununited head, which is in coxa vara, is frequently rotated upward by pressure from the lesser trochanter, and is actually replaced in its anatomical position (Figs. 2-A, 2-B, 6-A, and 6-B). When the osteotomy is performed through the intertrochanteric space, the obtusity of the angle formed by the neck and the shaft is increased, so that the hip joint somewhat resembles the upper end of the humerus, and leg length is consequently increased. In the writer's series the greatest amount of shortening was one and one-fourth inches and the least, three-eighths of an inch.

Pain. Of the three patients in whom the operation failed, two had considerable pain; the remaining twenty-two patients had varying degrees of pain in the hip and knee for an average of three months following the removal of the plaster-of-Paris spica. After this period the pain rapidly disappeared. A number of individuals complained of pain in the lower back, but this also gradually disappeared as function improved.

Union. In every one of the twenty-two cases with good end results there was a union of the ununited fracture, and in two of the three patients in whom the result was not satisfactory, there was questionable union (Figs. 1-A, 1-D, 3-A, 3-B, and 3-C). It is significant that callus was demonstrable between the osteotomized surfaces of the femur approximately six weeks following the operation in a preponderance of patients operated upon, and in the remaining patients two weeks later, thus permitting removal of the hip spica. By reason of the fact that the shearing force was eliminated, these patients were permitted to bear weight without any support. In one or two instances callus was demonstrated eight weeks after osteotomy, between the ununited head and neck and its distal point of apposition, but in most instances firm union was not evident much before three months following high osteotomy. This large incidence of union is quite remarkable and it is difficult to explain its causation. However, it is evident, as has been recently suggested by Wilson in discussing osteotomy following ununited fractures of the femoral neck in children, that the osteotomy plays a very important rôle in the revascularization of the neck, resulting in union. In the discussion of the end result of the effect of union following osteotomy, it is evident that the end result is far better in those patients in whom union of the ununited femoral head has been accomplished. Moreover, it is quite significant and, therefore, fair to assume that secondary changes such as aseptic necrosis and osteoarthritis are less likely to occur following osteotomy than after the other procedures advocated.

Postoperative Shock. As the operative procedure requires approximately twenty minutes for its performance, including the roentgenograms, and as there is very little operative hemorrhage, there should be no postoperative shock. In fact, none has yet been observed in our series.

Infection. The operative procedure entailed but a small incision and the minimum of tissue trauma, and all the wounds healed by first intention. There were no infections.

As the operation is designed to eliminate the femoral neck, the thigh is necessarily brought closer to the opposite side. Some patients, particularly the females, have complained of this difficulty, but this cannot be considered a serious contra-indication. A number of patients also complained of knock-knee. This occurred in very few instances, in those patients with greater shortening. When the shortening had been compensated, and knee-joint function improved, the patients were less conscious of this fact.

Some advocates of the reconstruction type of operation have emphasized the fact that their procedure is preferable because it does not require any form of external fixation such as a plaster-of-Paris spica, while the osteotomy necessitates bed confinement, and is particularly conducive to joint stiffness. This has not been the experience of the author because the plaster spica is applied with both the hip and knee completely relaxed and in slight flexion, and the abduction is achieved by forcing the distal osteotomy fragment inward rather than by abduction of the leg. As a consequence, the plaster-of-Paris spica is applied with no undue strain on the ligaments of the knee. The patient is placed in bed so that the foot hangs out, and thus permits him to be in a partial sitting position. It is the author's opinion that, unless there is an active knee-joint disease, there need be no fear of joint stiffness. Where one is apprehensive of any knee-joint stiffness because of osteo-arthritis or any other cause, a plaster-of-Paris spica may be applied with steel hinges incorporated in the plaster cast at the knee joint, thus permitting active and passive knee motion.

SUMMARY

In all cases of ununited fractures of the neck of the femur, where the head is viable, the high oblique osteotomy offers the simplest and most satisfactory method of treatment. By the operative technique described it is possible to determine the exact level of the osteotomy, thereby saving the length of the femur and ensuring security of the head on the end of the distal fragment. In a series of twenty-six patients treated by this procedure, twenty-two showed good results,—namely, satisfactory motion in the hip and knee, union of the ununited fracture, a minimum of shortening, and the ability to return to former occupations.

Whereas the osteotomy has been employed in the treatment of ununited fractures of the femoral neck since 1923, the first use of the high oblique osteotomy as described in this paper was in January 1935, and the last patient in this series was operated upon in January 1940.

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THE AUTOSYNOSTOSIS AS A SIMPLE METHOD OF SHORTENING THE BONE

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The choice of a method of equalizing the length of members of the body is frequently difficult. Since the operation for lengthening of the bones is a serious one, attended by many risks, the establishment of equality by the simpler method of shortening is preferred by many surgeons.

The operation for shortening the sound limb was first performed by Heine (Würzburg), but interest in it was not apparent until about the beginning of the present century. Since then, according to J. W. White [1], articles on its employment have been published in many countries. Previous to 1934, Dr. White performed forty-five operations for shortening the longer lower limb.

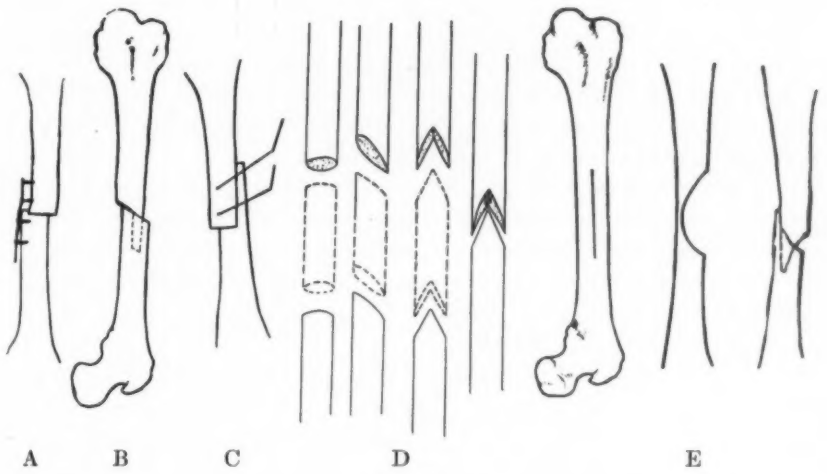

FIG. 1

Diagram showing various procedures. *A:* Deutschländer's; *B:* Calvé's; *C:* White's; *D:* Sorrel's; *E:* Kofmann's.

Defective limbs are frequently the result of muscle contracture or muscle wounds, or of contraction from injury to nerve trunks or roots, etc. In such cases there is distinct indication for surgical intervention to correct the defect or deformity. An operation may be indicated to correct defects as in Volkmann's ischaemic contracture, perhaps in combination with the operation on the contracted muscle, as reported by Sorrel. The question of shortening the sound limb has had much discussion, but the author shares the opinion that this means of length equalization is to be preferred to the lengthening of the defective limb since in the latter

FIG. 2-A

Case of manus vara. The distal end of the ulna is longer than that of the radius.

FIG. 2-B

After autosynostosis, the ends of the bones are at the same level.

there may be atrophy of scar tissue, contraction of muscle or tendons with adhesions, callus formation about the trunks of nerves, deformity of bone, and the result of old osteolytic changes, with the danger of retention of active germs and the possibility of infection.

Any operation for bone shortening should be simple and should give all possible assurance of successful union. However, this union may not always be obtained. In the author's experience, an oblique resection of a sound limb, performed twelve years ago, although surgically and postoperatively treated in the usual manner, failed to result in bony union, and secondary deformity developed.

Various methods of operating and of obtaining fixation have been reported. Deutschländer used aluminum plates, White overlapped the ends of the shortened bones and used pins, Calvé made an oblique cut, with a long quadrangular thorn at one end which he introduced into the marrow channel at the other end. For fixation he used strong catgut threaded through the bone. Sorrel employed "*resection en chevron*", introducing one sharpened end into a triangular cut at the other, strengthened by plates.

A communication of Dreyfus on the subject of camptodactylia, describing an operation to produce a stable contracture of the fingers by a method of shortening the bones of the hand, stimulated the author to follow this principle in a case of arthrogryposis.

The technique was simple. A long incision was made over the dorsum of the hand and the periosteum was incised for the greater part of its length, stripping it from around the sides of the two metacarpal bones. Then, with a sharp chisel, a four-centimeter incision was made along the shaft, leaving the cancellous portion with a thin part of the cortex.

The thin portion of the bone was then fractured and the fragments were pushed together to produce the desired amount of shortening, and the periosteum was closed with sutures.

The same operation was employed in a case of manus vara caused by an elongation of the distal end of the ulna, the result of an injury during childhood. In this case, resection of four centimeters at the distal end of the ulna was made, with fracture of the thin cortical area into the periosteal cuff; the fragments at the intersected portions were pushed into contact with each other.

FIG. 3-A FIG. 3-B

Case of rachitic deformity, before and after operation.

The same method was applied in a third case, deformity resulting from a wound of the cervical plexus causing marked atrophy and paresis of the upper limb. The hand had the shape of the classic "*main en griffe*". Shortening of the metatarsals according to the method described brought about an improvement in the position and function of the fingers.

In a fourth case, a boy with rachitic deformity of both lower limbs, so extreme that the lower epiphysis pointed inward at a marked angle and the fibula showed an outward bowing with an increase in length, so that in standing the foot rested on the outer border of the external malleolus, an osteotomy of the tibia was performed; the fibula was shortened according to the author's method by an excision of a piece of bone four centimeters in length at its middle third; the thigh was corrected and the leg fixed in plaster in normal position.

By this method, the preservation of the periosteal cuff prevents the interposition of muscle tissue, and the insertion of one bone end into the other secures the union of the fragments. The operation is simple, and no special surgical instruments are required. The method is less difficult and gives greater surety of success than the methods usually employed.

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RADIATION TREATMENT OF GANGLIA OF THE WRIST AND HAND

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Ganglia occurring about the joints, and those involving tendon sheaths, are embarrassing deformities, and may cause pain and weakness of the joint. Some patients prefer prompt treatment. The ganglia may develop after injuries such as sprains, or insidiously without known trauma. The pathogenesis is, in my opinion, probably traumatic. This opinion is based on the microscopic pathology of thirty-two sections of tissue, removed at operation, which revealed two cases of round-cell infiltration, and one case of hemosiderin pigmentation in the wall of the ganglion and surrounding adherent adipose tissue. Other theories, however, include herniation of the synovial membrane through an area of weakness in the tendon sheath or joint capsule, and colloid degeneration of the synovial membrane. Roentgen-ray therapy has been used at The Presbyterian Hospital with very satisfactory results.

Twenty-one patients with ganglia were treated by this method, and six of these have been followed for five years. The condition occurred with approximately equal frequency in males and females,—males eleven, females ten. The duration of these tumors, before consultation with the doctor, ranged from six months to twelve years with the average about two and one-half years. The occupations of the patients were student (six), clerical worker (six), housewife (three), nurse (two), and lawyer, chef, laborer, and child (one each). All but two of the tumors were located in the wrist. The two exceptions were in the tendon sheaths of the thumb and first finger. Of the twenty-one patients, eighteen complained of pain, fourteen of the presence of the tumor, and eleven of weakness of the joint.

The size, duration, and previous treatment of the tumor generally dictated the number of roentgen-ray treatments required to relieve the symptoms. Eight patients received only one treatment; one received seven, and another eight; the average number was nearly three. Of the eight patients who received one treatment, five were relieved of symptoms and three failed to return. Questionnaires answered stated that one of the three was not helped, but that the other two were slightly benefited by the treatment. The dosage of roentgen ray administered was 1.5 erythema immediately over the tumor. The patients were told to return in one month. If the tumor had disappeared and all symptoms were relieved, one treatment was considered sufficient. Where the tumor persisted, 1.5 erythema of radiation was given each month until results were

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obtained. If more than five treatments are necessary, the interval between treatments must be more than one month.

The tumor in the cases requiring seven and eight treatments gradually decreased in size, and increased in resistance to palpation. The actual process was one of fibrosis and destruction of endothelial secreting cells.

The value of the roentgen-ray therapy is revealed by the results of examinations and questionnaires. Seventeen, or 81 per cent., of the tumors had disappeared; fourteen, or 78 per cent. of those complaining of pain were relieved; and nine, or 82 per cent. of those complaining of weakness had normal return of function in the joint. In general, seventeen had good results, one was improved, two were not improved, and one was not heard from.

The author believes that this method of treatment is superior to the various procedures used in the past, and warrants a more extensive use. Ganglia which are aspirated or treated by the injection of a sclerosing solution such as sodium morrhuate, tend to recur. The old method of striking the tumor with the family Bible does not appeal to the patient's fancy, and seldom produces a cure. Surgical excision has produced the best results in the past with the least number of recurrences.

The advantages of roentgen-ray therapy over other procedures of treating ganglia are:

1. A higher percentage of cures is obtained.
2. There is no resulting scar.
3. Hospitalization is not required.

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OSTEOPATHIA CONDENSANS DISSEMINATA

Osteopoikilosis (Spotted Bones)

Report of a Case

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Osteopoikilosis, a disseminated condensing osteopathy sometimes called osteopecilia or Albers-Schönberg disease, is a congenital anomaly which is probably hereditary in nature. It occurs without symptoms, is seen in both sexes, and has been reported in every bone. It is usually diagnosed by chance when noted during roentgenographic examination for some other disorder. We were able to find fifty-two cases reported in the literature, but see no need for a detailed review at this time since Lowrey and Booth [8] have recently made an excellent survey of the literature, and listed a complete bibliography. Albers-Schönberg [1] is generally credited with having reported the first case in 1915. Roentgenograms of his patient, a twenty-one-year-old white male, revealed rounded or oval areas of spotted condensation in the spongiosa of the bone. Bloom [2] credited Stieda [14] with having described the condition in 1905 when he reported both roentgenographic and miscroscopic findings that are in keeping with the present concepts of the disease.

ETIOLOGY

The congenital origin of the disease has been well established. Von Bernuth [19] demonstrated the changes in a child eighteen days after birth. Heilborn, in discussing a report of Steenhuis [13], stated that he had seen the condition in a four-months-old foetus. Keyser, in discussing the same paper, stated that he had seen the changes in a child a few days old.

The hereditary factor has not been elucidated with certainty. Voorhoeve [20] reported three cases in one family. In making roentgenograms of a fourteen-year-old boy to elicit the cause of a chronic synovitis in the knee joint he demonstrated the linear (striae) type of changes consisting of vertical streaks of increased density in the long bones of the lower extremity, pelvic bone, sacrum, calcanei, scapulae, and the ribs. Roentgenograms of the boy's sister showed the same skeletal changes. The father showed similar changes. Roentgenograms of Voorhoeve's patient have been reproduced by Sutherland [16]. Wilcox [22] observed osteopoikilosis in a father and son. Svab [17] reported the condition in a father and two sons. Bloom found an isolated lesion in a metacarpal bone of the sister of his patient. Mascherpa [9] reported "slight changes" in a brother and a sister of his patient. Hirsch [6] reported the condition in a father and son; the father showed mixed lesions, but the son showed only lesions of the nodular type.

Numerous etiological theories have been advanced: Voorhoeve thought that osteopoikilosis and dyschondroplasia might well be different manifestations of similar endochondral disturbances. Nichols and Shiflett [11] reported a patient with multiple osteochondromata, proliferative periostitis, and clinical signs of hypothyroidism and hypopituitarism, who presented the typical changes of osteopoikilosis. Wilcox [21] thought it of interest to speculate that osteopoikilosis might be associated with parathyroid disturbance. Newcomet [10], who reported the first case in the American literature, thought the areas of increased density were ostoses which grew inward. Haack [5] has expressed the theory that the changes are possibly due to small venous emboli. Tuberculosis, scleroderma, diabetes, typhoid fever, and syphilis have been reported as concomitant diseases. The simultaneous occurrence of osteopoikilosis and dermatofibrosis lenticularis disseminata, as pointed out by Curth [3], is of interest in that both conditions involve tissues of mesenchymal origin, and apparently represent manifestations of similar lesions in different organs. Stubenrauch [15] pointed out that the areas may be due either to remnants of cartilage in the epiphysis or to constricted islands of intermediary cartilage.

PATHOLOGY

Roentgenograms show two types of lesions: the nodular (spotted areas of increased density) in the spongiosa, and linear striae (streaks of condensation) along the shaft. Both types of change are illustrated in Figures 1 and 2.

Schmorl [12], whose paper was abstracted by Nichols and Shiflett, is credited with having contributed the first histopathological description of osteopoikilosis. Gross examination of cross sections of the bone in his case showed that the areas of increased density varied from needle-head to pepper-grain size. They were irregular in contour and grayish-white in color. Those in the epiphysis were almost never in the terminal lamina to which the joint cartilage is connected. Those in the diaphysis usually lay in the periphery, and rarely in the axial plane. Microscopic studies showed the areas of increased density as numerous juxtaposed trabeculae which gradually merged into the surrounding spongiosa. The thickness of the trabeculae varied; the thicker ones consisted of lamellar bone arranged mostly parallel to the long axis of the bone. Some were grouped in the periphery, concentrically around blood vessels. Schmorl did not consider an endochondral origin probable, since the areas of increased density were not connected with the endochondral zone of growth, and cartilage was not observed in the areas described. He concluded that osteopoikilosis was probably a congenital anlage.

Stubenrauch from his histological studies concluded that osteopoikilosis develops by way of endochondral ossification, and he was able to show the early formation of one of these areas of increased density on the cartilage in this manner.

Only a few patients have been observed for any length of time. Jeter and McGehee [7] reported a case in which the changes had been known

to be present for a period of fourteen years. Newcomet noted no change in the lesions during four years' observation of his patient. Nichols and Shiflett followed their case for a period of seven years without any noticeable change. This lack of roentgenographic change is in keeping with the observations of Schmorl in that he found no signs of resorption or of production in the dense areas.

The bones have no tendency to fracture and there have been no previous reports of disturbance in their epiphyseal ossification or growth. Blood calcium and phosphorus, when determined, were found to be normal.

The case herein described presents both the nodular (punctate) and the linear (striae) types of lesions, and for the first time in the history of the disease, as far as we have been able to ascertain from the literature, presents a disturbance in the epiphyseal growth as well as various contractures and deformities, the cause of which has not been determined. The patient has been observed for a period of five years. Roentgeno-

FIG. 1

Roentgenograms of the right knee. Tibial and femoral epiphyses, as well as the patella, show typical "spotted-bone" changes, whereas the diaphyses present striae areas of increased density. The enlargement of the medial aspect of the lower end of the diaphysis, and the epiphysis of the femur are not involved in the process. Roentgenograms of the left knee showed identical changes.

FIG. 2

Lateral roentgenogram of right foot showing involvement of the epiphysis of the fibula, all tarsal bones, proximal heads of the second, third, and fourth metatarsals, distal heads of the first, second, and third metatarsals, and proximal phalanx of the great toe. Striae changes visible in the upper two thirds of the tibia are not present in the lower third. Roentgenogram of the left foot showed similar changes in the epiphysis of the fibula, calcaneum, and cuboid, and, to a lesser extent, in the astragalus and second cuneiform.

graphic studies of other members of the family failed to show even the slightest suggestion of any osteopoikilosis.

CASE REPORT

R. F. W., an eight-year-old white male, was admitted to the Children's Hospital School on July 2, 1936, complaining of a deformity of the left foot of four years' duration, and of an asymptomatic enlargement of the medial condyle of the right femur of two years' duration.

On examination the patient stood with an equinus deformity of the left foot. The left lower extremity was adducted and the right was abducted and externally rotated. The pelvis was rotated counterclockwise and tipped forward. The spine showed a long right thoracolumbar scoliosis which disappeared when the patient was seated. The

medial condyle of the right femur presented a smooth, regular enlargement which was not tender and did not have any increased local heat or redness. There was a genu valgum deformity of the right knee with a lateral displacement of the patella, but with a normal range of motion. The right foot presented a slight varus deformity and a hallux valgus with the great toe overlapping the second toe. The proximal phalanx of the second toe was enlarged. The fourth toe showed a hammer-toe deformity. A contracted Achilles tendon held the left foot in an equinus position which could not be forcibly corrected. There was no muscular weakness and the reflexes were present.

Roentgenograms showed punctated and striated changes throughout the pelvis, the femora, pubes, the right patella, and the tarsal and metatarsal bones, as well as the phalanges of the lower extremities (Figs. 1 and 2). Roentgenograms taken elsewhere one year preceding admission showed similar changes.

The laboratory findings were as follows:

Urinalysis—negative
Hemoglobin—100 per cent.
White blood count—8,920
Blood calcium—9.7 milligrams
phosphorus—4.0 milligrams
Phosphatase—5.4 milligrams
Wassermann—negative

In a biopsy of the body of the left os calcis the bone was found to be of a normal consistency and hardness. Sections showed adult cartilage, calcified cartilage, and cancellous bone. In one area there was some variation in the thickness of the trabeculae but no increase in their contiguity. The failure of a large section of the left os calcis to show changes demonstrated in the roentgenograms was thought to be in keeping with the previously reported findings of a peripheral distribution of the areas of increased density.

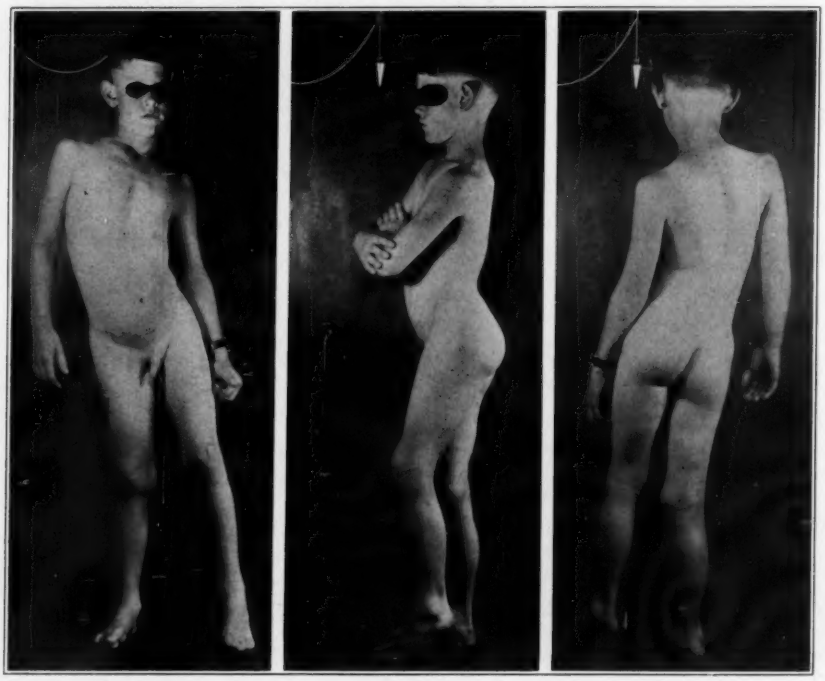

FIG. 3-A FIG. 3-B FIG. 3-C

Photographs of patient. Note contractures about toes of the right foot, equinus deformity in the left ankle, and enlargement of the medial condyle of the right femur.

DISCUSSION

No definite conclusions concerning the etiology of osteopathia condensans disseminata have been reached and no new theory advanced. That it is a congenital anlage is fairly well established. The hereditary factor has not been elucidated with certainty.

The reported case is of interest in that it (1) shows both punctate and striae types of lesions, (2) has been followed for five years, and (3) presents a disturbance in the growth of one of the epiphyses as well as numerous tendon contractures and deformity.

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AN UPPER-ARM FRACTURE FRAME

BY H. K. CHRISTIE, CH.M., F.R.C.S., F.R.A.C.S.,
WANGANUI, NEW ZEALAND

From the Orthopaedic Department, Wanganui Hospital

This simple apparatus was devised in the first instance to deal with fractures above the condyles of the elbow in children. It provides both the longitudinal extension and the upward lift required to restore the short lower fragment to its correct position. It ensures the maintenance of external rotation, and it accomplishes most of the reduction automatically with a minimum of trauma to the elbow. We have been so satisfied with it that we have adopted it as one of our standard appliances.

CONSTRUCTION OF THE FRAME

Figure 1 shows the arrangement of the apparatus for a fracture of the surgical neck (adduction fracture) of the humerus. The frame itself is a simple gallows fastened to the table with brackets and screws. Anyone with a saw and screw driver can make it in a few minutes. On top of the gallows are extension pieces into which a pulley may be screwed to give the required degree of elbow flexion or extension. The table may be any small table or even the bedside cupboard. Its top is flush with the

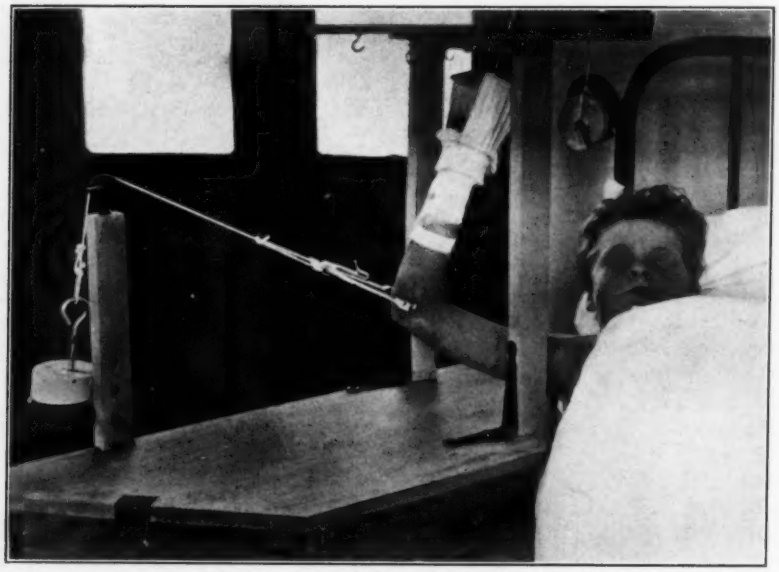

FIG. 1

Upper-arm fracture frame showing arrangement for fracture of the surgical neck of the humerus.

mattress, which in turn rests upon fracture boards. In Figure 2 is seen a more adaptable table which fits either the left or right side of the bed. It has an adjustable upright attached, so that the line of traction may be varied to suit the fracture. The wide legs permit the x-ray tube to be swung underneath, so that the rays come up from below at an angle, while the cassette is held across the elbow flexure.

In using this apparatus for supracondylar fractures, traction is made along the surface of the table, on which the arm rests. The four hooks visible in the picture are screwed into the surface of the table, two by each bracket, as shown by the dots in Figure 2. A piece of stout calico is fastened onto the hooks, and, passing over the shaft of the humerus, holds it down on the surface of the table. This provides countertraction to the vertical weight.

When the patient is admitted to the hospital the arm is put into the frame and horizontal and vertical ten-pound weights are attached and kept in place for twenty-four hours. Traction with fine Kirschner wire is applied for a supracondylar fracture, but strapping is satisfactory for a humeral neck fracture. A few inhalations of ethyl chloride, or the injection of novocain, is required while the wire is passed through the olecranon at about the line of the humeral axis. This will clear the ulnar nerve, and the radio-ulnar joint.

The use of wire traction through the olecranon is open to criticism. The wire should be a fine one, and should be removed in three or four weeks. There is no other way of getting continuous extension—the keynote of success—in a supracondylar fracture. During the past two years there have been no complications as a result of such traction.

The elbow position at 90 degrees and the longitudinal traction which corrects the overlap are safeguards against ischaemia. When the

FIG. 2

Upper-arm fracture frame showing the arrangement of the table legs, permitting an x-ray tube to be swung underneath. The table fits either side of the bed. An adjustable upright carries the pulley for longitudinal extension. The hooks seen on the upper part of the frame are screwed into the table top where the dots are shown, so that the humeral shaft can be held down with a "ground-sheet" to counter the upward extension in supracondylar fractures.

roentgenogram shows no further overlap, usually the next day, manipulation under a very brief anaesthesia corrects the backward displacement. Both corrections are maintained in a child by a four-pound pull

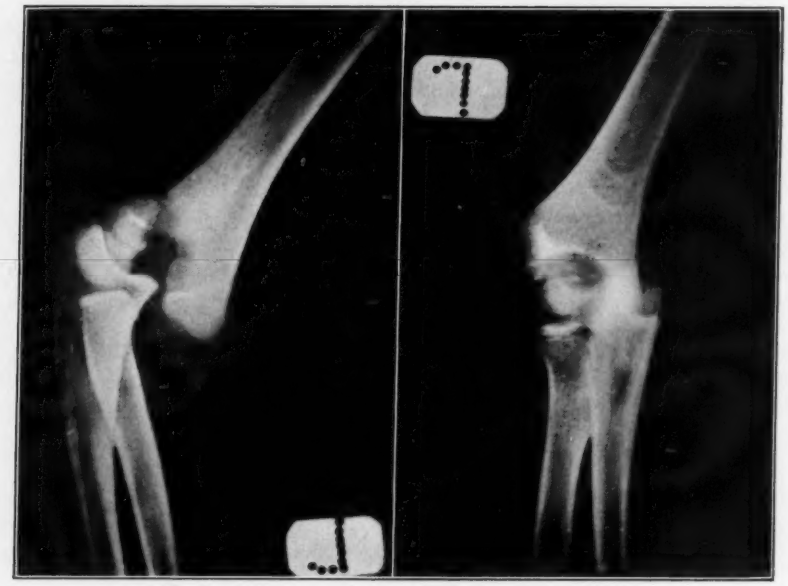

FIG. 3-A

Case 1. Fracture of the internal condyle and epicondyle.

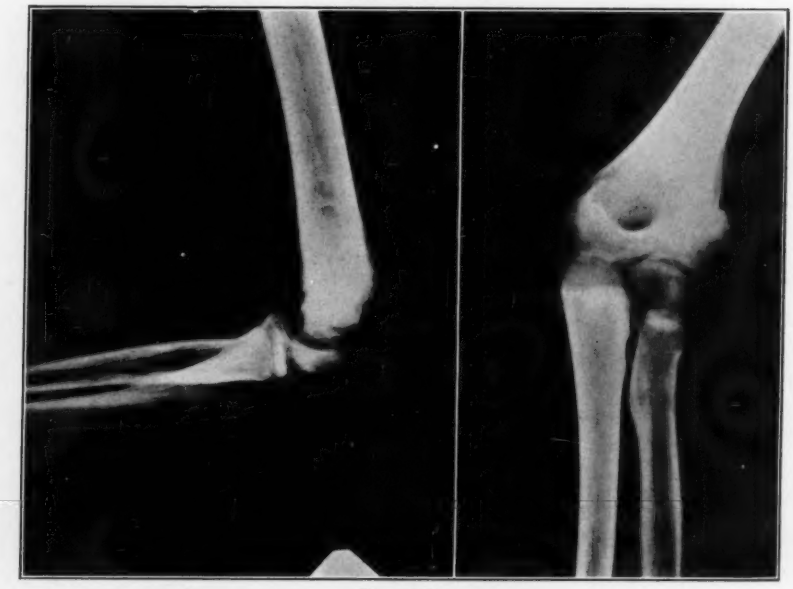

FIG. 3-B

Case 1. Two months after treatment in the frame.

over each pulley. The manipulation should be completed at one time, as subsequent manipulations spread the haematoma and promote excess callus. The rapid formation of callus in children may preclude a reduction by the end of ten days.

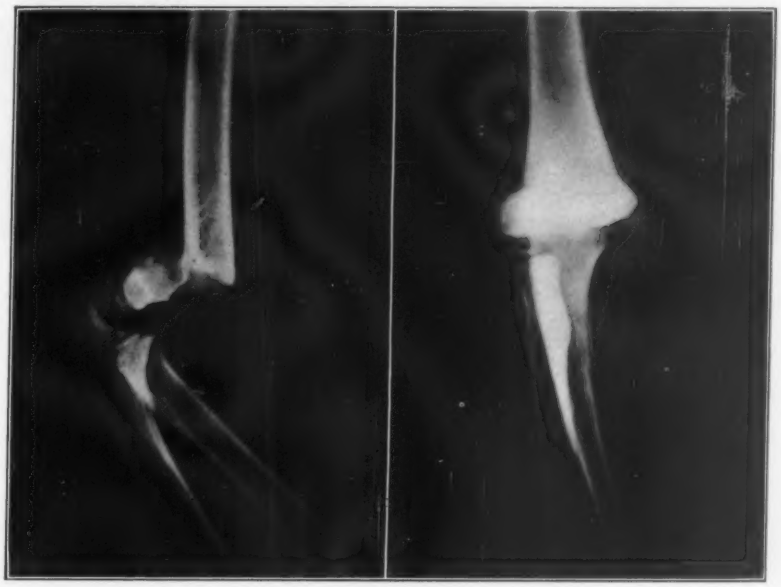

FIG. 4-A

Case 2. Supracondylar fracture of the humerus.

FIG. 4-B

Case 2. After treatment in the frame for four and one-half weeks.

FIG. 5-A

Case 3. Adduction fracture of the neck of the humerus.

FIG. 5-B

Case 3. Six weeks after treatment in the frame in abduction of 90 degrees.

After three weeks, extension is discontinued, the arm placed in a sling, and active movements and massage commenced.

A few roentgenograms are reproduced to show some humeral fractures reduced in this very sure and convenient apparatus (Figs. 3-A, 3-B, 4-A, and 4-B).

Almost all humeral fractures may be treated in the frame, except impacted abduction fracture of the humeral neck in adults. These should be treated in adduction.

Although especially designed for children, a slightly larger frame is suitable for adults. A plaster strip may be used in addition for a shaft fracture.

The dislocated shoulder combined with a fracture of the tuberosity or avulsion of the supraspinatus, is especially suitable for treatment by the frame. After reduction of the dislocation, traction in abduction of 90 degrees restores the torn capsule as well as reduces the separated tuberosity.

ADVANTAGES OF THE UPPER-ARM FRAME

1. *Simplicity.* It can be constructed by anyone and used in the patient's own home.

2. *Control.* Any desired degree of abduction, external rotation, and flexion at the shoulder, and of flexion or extension at the elbow can be maintained.

3. *Facility.* Manipulation can be carried out in the frame, with the help of its traction. Roentgenograms can be taken from the side or from below. Plaster strips may be applied at any stage with no risk of redisplacement.

4. *Convenience.* It guards against ischaemia, saves time, and reduces manual manipulation to a minimum.

5. *Comfort.* The patient is at once both relieved of his pain, and put under complete control.

TREATMENT OF ACUTE ACROMIOCLAVICULAR DISLOCATION

BY VERNON L. HART, M.D., MINNEAPOLIS, MINNESOTA

Complete acute traumatic separation of the acromioclavicular joint is a serious and not uncommon injury. A fall or blow on the prominence of the shoulder results in a rupture of the acromioclavicular and coracoclavicular ligaments. There is a downward displacement of the acromion and an upward displacement of the clavicle. The deformity can be reduced by pushing upward on the elbow while pressure is applied downward over the lateral portion of the clavicle. The deformity recurs as soon as the pressure is released because stability of the joint depends entirely upon ligaments and not upon anatomical configuration of the two bones. Proper treatment demands complete reduction of the dislocation and uninterrupted maintenance of the reduction until the ligaments have healed. Adhesive dressings are uncomfortable and inefficient and too frequently permit an acute dislocation to become a chronic one which requires surgical correction.

FIG. 1

Plaster-of-Paris shoulder spica with adjustable padded webbing straps and buckles, for treatment of complete acute traumatic acromioclavicular dislocation.

FIG. 2

Plaster-of-Paris shoulder spica with upper half removed.

During a period of ten years the writer has used a method of treatment (Fig. 1) which has proved to be comfortable and efficient. A plaster-of-Paris shoulder spica is applied while the scapula is elevated with the arm in a position of about 45 degrees of abduction. The plaster spica

anchors the elevated acromion. Downward pressure can then be applied over the lateral portion of the clavicle by means of two two-inch webbing straps with buckles which are incorporated within the plaster spica during its application. The continuous pressure over the clavicle is made more comfortable by placing a layer of felt and a firm rubber sponge between the webbing straps and the skin over the clavicle. This arrangement of cast and adjustable padded webbing straps fulfills the requirements of treatment, which are continuous and uninterrupted reduction of the dislocation, with comfort, until the ligaments have healed. A period of six to eight weeks is required for healing of the ligaments.

After the cast has been applied a window about one and one-half inches in diameter should always be removed from the cast at the elbow to prevent pressure necrosis of the skin over the internal epicondyle, and pressure neuritis of the ulnar nerve.

After the fourth week of treatment, the upper or cephalad half of the plaster which encases the extremity is removed (Fig. 2). The patient is instructed to use actively all motions of the elbow joint, and abduction and external rotation of the shoulder. The complete range of elbow and shoulder motions will then have been restored when the entire cast is removed at the end of six to eight weeks.

CORACOCLAVICULAR ARTICULATIONS

BY P. DAVID NUTTER, M.D., HUNTINGTON, WEST VIRGINIA

From the Bone and Joint Service, Receiving Hospital, Detroit, Michigan

Contrary to the belief expressed in the works of most authors on coracoclavicular articulations, these joints are not rare conditions.

The author's attention was first called to the existence of these joints by Gradoyevitch's article describing the x-ray findings of a case with evidence of bilateral coracoclavicular joints. In this report, he stated that prior to the discovery of his case only fifteen other cases were known to medical science, ten of which had been proved anatomically and five roentgenographically.

The purpose of this article is to give a roentgenographic description of this joint and to present evidence of the frequency of its occurrence. The discussion and findings relative to the anomaly as presented by other authors will not be repeated here, since this was adequately covered in Gradoyevitch's work.

Absolute proof of the existence of this joint, as Gradoyevitch states, "demands evidence of two cartilaginous articular surfaces,—a capsule and a synovial membrane", the essential anatomical structures of all true joints. Although all these separate anatomical structures cannot be demonstrated by ordinary roentgenographic methods, the presence of a large clavicular bony process, which has a facet that conforms to the adjacent end of the coracoid, appears to be as adaptable to this surface

FIG. 1

Case 6. Roentgenogram of chest showing the presence of bilateral coracoclavicular articulations.

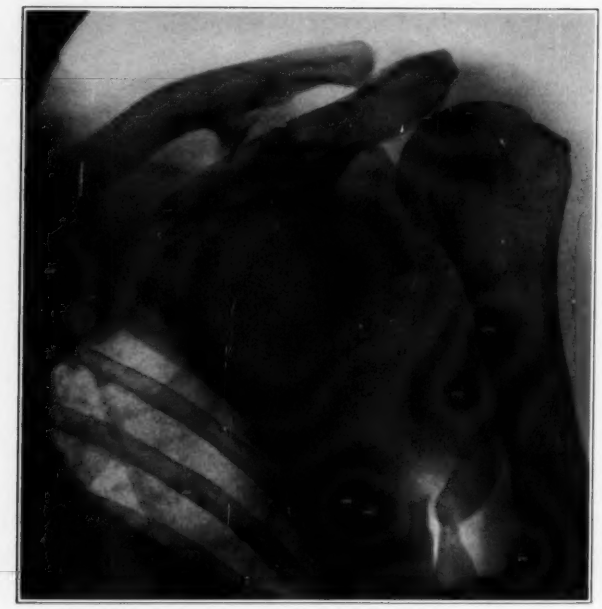

FIG. 2

Case 8. Roentgenogram of left shoulder showing the presence of a typical coracoclavicular articulation.

as the surfaces of other true joints are adaptable to each other, and with the coracoid forms an interarticular space, leaves little doubt that the other joint structures are also present.

These articular bony outgrowths on the clavicle are present at the site of the tuberosity for the attachment of the conoid ligament. Often in an adult clavicle this tuberosity can easily be defined roentgenographically. Sometimes this tuberosity is as large as the apophysis of a coracoclavicular joint, but it does not possess the same smooth, concave articular facet. In some cases no conoid tuberosity can be demonstrated by roentgenograms; the outline of the bone at this point is smooth and continuous with the general outline of the inferior surface of the clavicle.

Of 1000 unselected roentgenograms of adult shoulders taken for various conditions at Receiving Hospital, twelve roentgenograms, or 1.2 per cent., gave evidence of coracoclavicular joints. Of these twelve patients with coracoclavicular joints the condition was bilateral in six. In only two of the other cases were roentgenograms taken of both shoulders.

This condition was present in eleven male patients and one female. Unfortunately a record of sex was not kept in the original 1000 cases; therefore, this does not give an accurate sex distribution of this condition.

Five cases had roentgenograms of the chest for suspected lung pathology. Three of these gave roentgenographic evidence of bilateral symmetrical apophyses, with facets adaptable to each corresponding coracoid process. In one case, all of the left shoulder was not included on the plate, and in the remaining one an articular process was present on the left clavicle, but on the right there was only a tuberosity for attachment of the coracoid ligament. This did not possess the smooth, concave surface similar to that of the left side.

In four cases roentgenograms were taken of the shoulders. Three of these patients had suffered recent injury, and one (Fig. 2) complained

of pain over the subacromial bursa. Only one patient in this group had an x-ray taken of both shoulders. This revealed evidence of a coracoclavicular joint on the left. On the right, the conoid tuberosity was prominent, but its inferior surface was rounded and did not possess an articular facet. Examination of both shoulders showed them to be symmetrical with normal motion.

Only three patients in the entire series had detailed physical examinations for evidence of presence of coracoclavicular joints. In these no abnormality was demonstrated that could be attributed to their presence.

From this study it can be concluded that the anatomical and physiological significance of these joints is only academic. However, inasmuch as they are true joints, it can be presumed that they are not exempt from any of the various pathological conditions which affect any other joint.

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A UNIVERSAL SPLINT FOR EMERGENCY IMMOBILIZATION OF FRACTURES OF THE EXTREMITIES, NECK, AND BACK

BY ALEXANDER L. BASSIN, M.D., NEW HAVEN, CONNECTICUT

From the Section of Orthopaedic Surgery, Yale University

The splint described here has a variety of uses in the emergency immobilization of fractures and has been successfully used in our clinic as part of the ambulance equipment. It is a stable and simple mechanism for the immobilization of an extremity, neck, back, or pelvis. Additional advantages are that the mechanical adjustments are not complicated, the apparatus can be applied quickly and easily, and can be collapsed to an over-all length of thirty-three inches for storage (Fig. 4). It occupies considerably less space than some of the other conventional splints. Because of its compactness it can be carried in a suitcase as equipment for emergency care of athletic teams. Fitted into a flat canvas case, which also contains bandages and first-aid dressings, it can be carried in the physician's car, or made available as emergency equipment in first-aid stations and public vehicles, such as buses and trains, etc.

For adequate immobilization the standard emergency splint equipment must include at least two of the customarily used splints to be suited to the diameter and length of the upper and lower extremities in

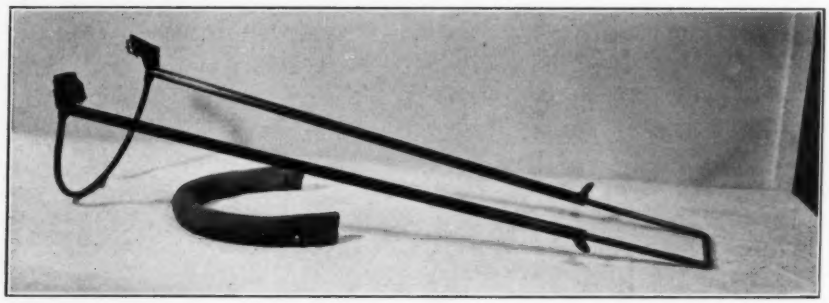


FIG. 1

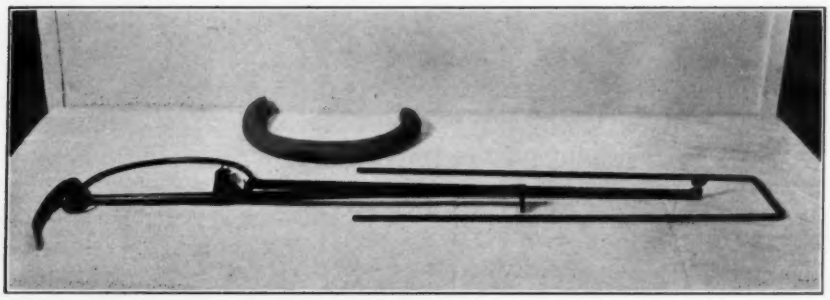


FIG. 2

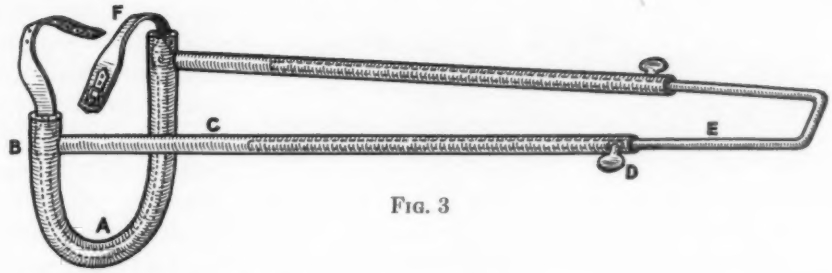


FIG. 3

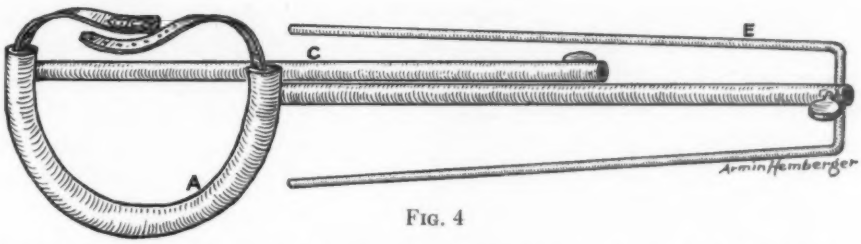


FIG. 4

adults and children. This universal splint is interchangeable for either the upper or lower extremities and is also adjustable to their length and diameter.

The splint is composed of two major parts. One part consists of a half ring (*A*), nine and one-half inches between the free ends and seven inches in depth, at the ends of which are attached two tubular rods (*C*). These rods, which are twenty-four inches in length and 0.33 inches in diameter with an 0.26 inch bore, form the side arms of the splint and are joined to the ring by means of two right-angled joints (*B*). A strap (*F*) joins the free ends of the half ring which may be covered with either leather or rubber from a baby-buggy tire. The second part consists of a U-shaped rod (*E*), with arms twenty-two inches long and 0.24 inches thick, which fit easily into the tubular side arms of the splint. The base of the U-shaped rod is five inches in width. The position of the rod within the tube is maintained by means of thumb screws (*D*).

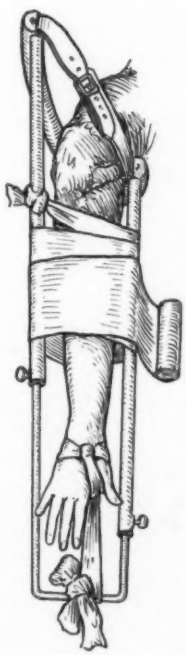


FIG. 5

The width of the splint can be adjusted, by altering the angles between the ring and the side arms, from approximately five inches (Fig. 5) to nine inches (Fig. 6),

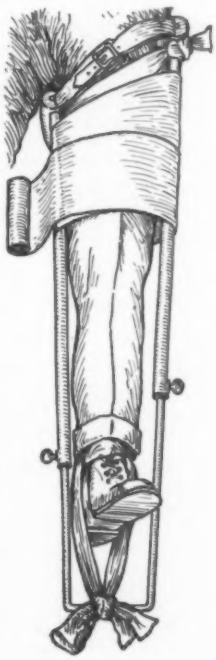


FIG. 6

FIG. 7

and, as it can thus accommodate variations in the diameter as well as the length of the extremity, it is applicable for use with children and adults.

When used for the immobilization of the head, neck, and back, and for injuries to the pelvis, the half ring is maintained at right angles to the side arms of the splint, and the length of the splint is adjusted to extend just beyond the level of the greater trochanters (Fig. 7). The thumb screws are set so that they remain flat. The splint is passed beneath the individual, and the head, neck, and trunk are held in place by means of bandages. Such immobilization provides adequate stability and protection during transportation of the patient.

Because of its adjustability the splint may also be used in the bed care of fractures requiring traction-suspension treatment.

A SIMPLE CORRECTIVE DEVICE FOR HALLUX VALGUS

BY MARTIN BATTS, JR., M.D., GRAND RAPIDS, MICHIGAN

A simple, efficient, inexpensive, and comfortable corrective device for hallux valgus is difficult to find. The device herewith illustrated meets all these requirements. Its action is similar to that of the stretched

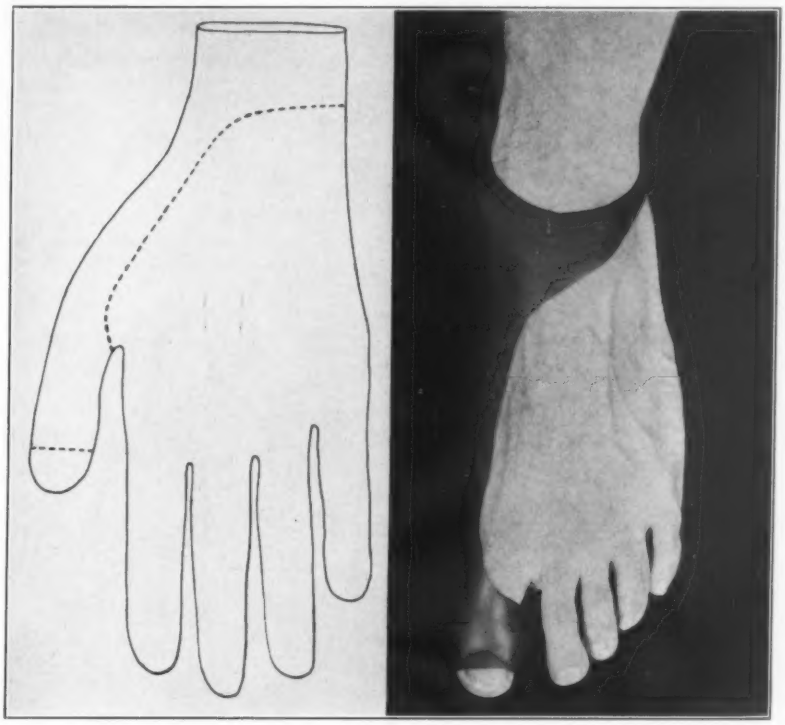


FIG. 1

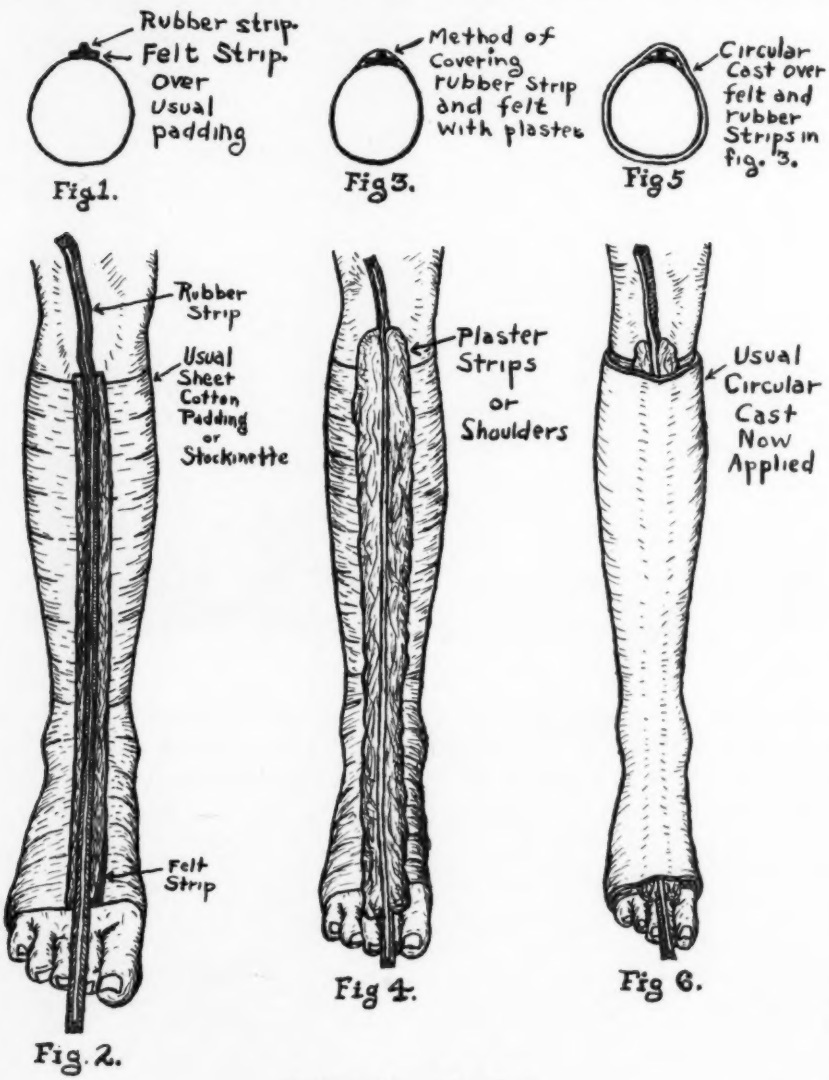
and non-functioning abductor hallucis. A rubber glove is cut in the manner indicated in Figure 1, and the appliance is immediately ready for wear. It has been found to be especially useful in maintaining a post-operative correction of a hallux valgus.

A SIMPLE METHOD OF APPLYING PLASTER CASTS TO PROVIDE FOR EASY REMOVAL

BY WILLIAM J. WILSON, M.D., NEW YORK, N. Y.

From the New York City Hospital, Welfare Island, New York

Because of the difficulty encountered in removing snugly fitting plaster casts, the following method of application has been devised. Casts applied in this manner are as comfortable as the usual circular cast and



Method of Applying Cast

retain all of its advantages. For the sake of clarity the description will be for a toe-to-knee cast, as shown in the accompanying illustrations. However, this same principle may be applied to other casts.

An ordinary rubber automobile fan belt may be secured from any automobile supply or hardware store. The loop is cut so that the fan belt becomes a long strip, a cross-section of which is shown in Figure 11. The strip is rubbed with paraffin to prevent its sticking to the cast when used.

The foot and leg are first enclosed in stockinette or wrapped with sheet cotton. A strip of piano felt two inches wide and long enough to extend entirely through the cast is laid along the anterior surface of the foot and leg. On top of this the rubber strip is laid, with its widest surface in contact with the felt (Figs. 1 and 2). Two strips of plaster bandage are

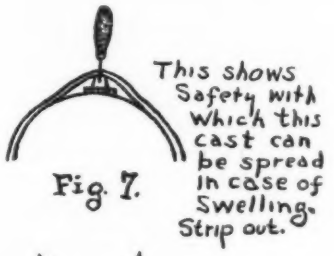


Fig. 7.

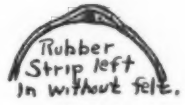


Fig. 9.

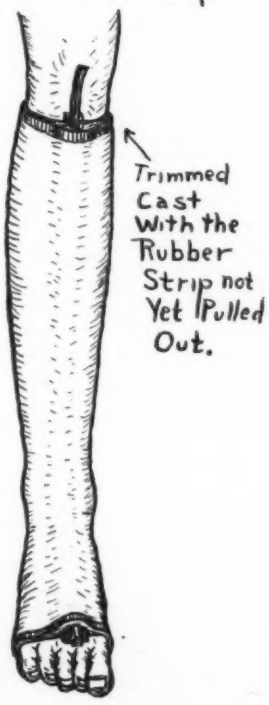


Fig. 8.

Fig. 10

Fig. 11.

placed on either side of the rubber strip, covering the felt strip, to restore a smooth rounded contour (Figs. 3 and 4). Over this a circular cast is applied in the usual manner (Figs. 5 and 6). The cast is trimmed and finished as desired (Fig. 8), and the rubber strip pulled out as soon as the plaster has set, but while it is still wet. One hand placed over the instep while the strip is pulled with the other eliminates any danger of breaking the cast.

The finished cast is a circular one with a grooved inner surface extending through it. The margins of the groove are amply padded and cause no discomfort whatsoever to the patient. This cast is easily removed as the groove readily admits the lower jaw of a conventional cast cutter, as shown in Figure 10. The cast is then opened with a cast spreader and removed.

This method of application also provides a safe method of splitting and spreading a portion of the cast when unexpected or postoperative swelling of the part occurs (Fig. 7). The underlying groove keeps the knife or saw from contact with the skin.

Certain modifications of this method can be made to suit the individual, such as substitution of two or three thicknesses of narrow sheet cotton for the felt. This is adequate in cases where weight is not borne on the part, but with walking iron casts the felt strip should be used or the rubber strip left in. In walking iron casts, this method of application is especially useful as the extra plaster necessary to fix the walking iron usually makes the cast more difficult to remove, but in this type of cast all the plaster is easily cut at the same time.

This method has been used on quite a few patients at the New York City Hospital with very satisfactory results. Only a few minutes more are required for application and the extra time is amply repaid by the ease and rapidity with which the cast is removed. A walking iron cast of this type has been removed in a little less than three minutes.

The cast retains all the strength of a conventional circular cast. It has the advantage of greater strength and more complete immobilization than casts routinely split over a tin strip, without the danger of having the knife leave the tin strip and cut the patient. The rubber strip, which is removed each time, may be used in the application of any number of casts.

VITTORIO PUTTI

March 1, 1880—November 1, 1940

Vittorio Putti was Professor in the University of Bologna, Surgeon-in-Chief of the Istituto Ortopedico Rizzoli, a founder of the Société Internationale de Chirurgie Orthopédique et Traumatologie and President of its 1936 Congress, Honorary Member of the British Orthopaedic Association, the American Orthopaedic Association, Corresponding Member of the American Academy of Orthopaedic Surgeons, and many other national organizations. He was a bibliographer, medical historian, orthopaedic investigator, and teacher of surgeons. He had been a Foreign Editor of *The Journal of Bone and Joint Surgery* since January 1928.

Bologna was a Roman city. The Cathedral of San Pietro e San Paolo, built in part from the Roman remains, was erected in the fourth century. The city has long been a seat of learning, and legends attribute the founding of the famous University of Bologna to Theodosius the Great in 425 A. D. Among the students of this University were Dante (1265–1321), Petrarch (1304–1374), and Luigi Galvani (1737–1798), the discoverer of galvinism. One of the most famous professors was the anatomist Marcello Malpighi (1628–1694). In 1262 the students of the University were said to number nearly 10,000. The student population has decreased, but the Medical School of the University is still outstanding.

The Istituto Ortopedico Rizzoli is situated on a hill on the outskirts of this fascinating old city and occupies the picturesque buildings of a Benedictine Monastery known as San Michele in Bosco. The early years of this institute for crippled children were not noteworthy, until Alessandro Codivilla, modest and skillful master, became its Director and Surgeon-in-Chief. This great general surgeon, after excelling in the surgery of the gastro-intestinal tract and the brain, devoted his talents to orthopaedic surgery, and the "Istituto" became world-famous. Codivilla made original and important contributions to the surgery of fractures and the methods of tendon transplantation, and to the development and standing of the specialty.

At his death in 1912 Codivilla was succeeded by Vittorio Putti, the son of a well-known surgeon who was for many years Professor of Surgery in the University of Bologna. Putti had first become identified with the Istituto Ortopedico Rizzoli in 1903 when Codivilla had appointed him as an assistant. Following two years of study in European clinics, he returned to the institution in 1909 as Vice-Director, and in 1914 became Director and Surgeon-in-Chief of the Istituto. He was also Professor of Orthopaedic Surgery at the University of Bologna.

In 1922 he opened the country branch which provided for the care of 100 cases of surgical tuberculosis, and as Director of this hospital (Istituto dio terapico Codivilla di Cortina d'Ampezzo) in the Dolomites he found frequent escape from his overstrenuous city life.

A brilliant student, a wide reader, an able administrator, a resourceful and skillful surgeon with a mechanical bent, he enhanced the reputation of the Istituto Rizzoli, and like Codivilla, made lasting contributions to the history of medicine and to the technique of orthopaedic surgery.

In addition to being a tireless and exacting trainer of young surgeons, he encouraged his associates to become familiar with the history of medicine and the contributory sciences, to strive for exactitude in thought and action, and to appreciate beauty not only of art and nature but of character. His sanctum sanctorum, which he shared with his helpers, was the library (La Biblioteca Umberto I). On the walls of this dignified room are the same beautiful frescoes, executed by Canuti, that had given joy to the monks, and on its shelves are books and manuscripts covering a period of over 400 years.

VITTORIO PUTTI

By his numerous original contributions he became an international leader, a pioneer and an authority on bone and joint surgery, especially on congenital dislocation of the hip, its preluxation stage and its automatic reduction by the *divaricatore*, arthritis, arthroplasty, "sciatica", the forcible manipulation of adult club feet, the open treatment of fractures and the use of skeletal traction and metal fixation, the equalization of leg lengths by bone lengthening, spinal anomalies, cineplastic amputations and artificial limbs, and the surgical treatment of the residual effects of poliomyelitis. He published many monographs, not only on strictly medical and surgical subjects, but also on non-medical subjects, as well as translations of old medical works. His large quarto, "Berengario da Carpi" published in 1937, represents not only a profound and extensive piece of research, but the best biographical study of this great surgeon and anatomist who antedates Vesalius. This work alone places him among the great medical historians. His latest volume, published in 1940, is entitled "Cura operatoria delle fratture del collo del femore".

He was active in organizing *La Chirurgia degli Organi di Movimento* which was first

published in 1917. He continued as the editor of this outstanding medical journal until his death.

He was an accomplished linguist and lectured by invitation in practically every country, including the United States, England, France, Germany, and Russia. He visited England and America often and loved them both. He was a guest of the American Orthopaedic Association at its Boston Meeting in 1921, and delivered later the Lane Lectures in California. He was the guest speaker at the Congress of the American College of Surgeons held in Boston in 1934 and in Chicago in 1937.

His titles were too numerous to mention for he was a corresponding, honorary, or active member of most of the orthopaedic societies of the world. His honors included civilian, medical, surgical, military, and academic recognition. He received from the King the title of Grand Officiali of the Crown of Italy.

Putti enjoyed the friendship of a host of physicians and surgeons throughout the world and was an inspiration to them. Those who knew him well discovered a depth of feeling and a capacity for friendship which were the true attributes of his character. After the death of his professional ideal, Sir Robert Jones, he wrote the following letter in English to an American colleague. Its exquisite diction suggests a faith and an affection which are almost religious in nature.

"Dear ———

The death of our unforgettable Sir Robert has made me think a great deal about you in these days. It is a great friend who has left us, and I think that all of us who loved him feel the need of uniting together in his memory.

Let our friendship find in his memory strength of faith and reason of comfort.

Do not forget me and believe me

Affectionately yours,

PUTTI"

Vittorio Putti will rank among the great orthopaedic surgeons of all time—great in heart as well as in mind and hand.

REGINALD CHEYNE ELMSLIE

1878–1940

The death of Reginald Cheyne Elmslie, on July 24, 1940, at the age of sixty-two years, has robbed British orthopaedic surgery of one of its stoutest champions. The son of Captain J. A. Elmslie, R.N.R., he was, through his great-grandfather, Dr. John Cheyne, descended from three successive John Cheynes, all of whom practised surgery in Edinburgh.

At the age of seventeen, Elmslie entered St. Bartholomew's Hospital where he obtained a number of scholarships and qualified with the Conjoint diploma in 1901. In 1904 he was awarded the Gold Medal in the examination for the Mastership of Surgery and also became a Fellow of the Royal College of Surgeons. In the following year, when he was awarded the Jacksonian prize of the College for his essay on "The Pathology and Treatment of Deformities of the Long Bones due to Disease occurring during and after Adolescence", it was already clear in which direction his tastes lay. Then came a number of increasingly responsible appointments, but one of them, generally regarded as nothing more than a stepping-stone, left a permanent mark on his intellect. For five years Elmslie held a demonstratorship of pathology at St. Bartholomew's Hospital; and in later life he never lost his interest in the pathology of crippling conditions, to which subject he made a number of valuable contributions.

He was the first man in England seriously to apply clinical pathology to orthopaedics and one of the few orthopaedic surgeons who regarded a microscope as an essential part of his equipment. He was appointed to the staffs of the Metropolitan Hospital and the Royal National Orthopaedic Hospital. In 1912, he became Surgeon-in-Charge of the Orthopaedic Department at St. Bartholomew's Hospital, where he was the first member of the staff to devote himself exclusively to the practice of orthopaedic surgery. It was no easy task for him to build up a department in a hospital as conservative as it was venerable—indeed it was not until he had been there for many years that he obtained an operating theatre of his own—and he was never given satisfactory accommodations for in-patients or for a massage department. However, patients came to the new department in numbers, and his teaching quickly attracted many eager pupils. As surgeon to the Orthopaedic Hospital he spared no effort to bring about the transition from the "brace-and-tenotomy" orthopaedics of the last century to the comprehensive science into which this great branch of medicine has now grown.

A catalog of Elmslie's many other offices is a necessary preliminary to an appreciation of his character. In 1905 he was appointed the first inspector of crippled children in the enormous area controlled by the London County Council; he was a pioneer in this invaluable preventive and therapeutic work. After the war of 1914–1918 he presented a comprehensive and scholarly report, at that time unique, on the prevention and treatment of crippling diseases in children, which ultimately formed the basis for the legislative reforms that led to the establishment of orthopaedic schemes throughout the country. He was one of the founders and a most active member of the Central Council for the Care of Cripples, and in 1938 became Chairman of its Executive Committee. At the Fourth World Conference of Workers for Cripples held in London in July 1939, he read a remarkable paper, showing how the organization of orthopaedic work had led slowly but surely to a striking decrease in the incidence of severe crippling in Great Britain. Elmslie was instrumental in obtaining the Charter for the Society of Massage and Medical Gymnastics, of which he was Chairman from 1929 to 1935. During the last war he was chiefly responsible for making the Military Orthopaedic Hospital at Shepherds' Bush into a world-famous center for the treatment of war injuries; he was also surgeon to the Pensions' Hospital at Roehampton, and was later appointed Consulting Surgeon to the Ministry of Pensions. He served as the only medical member of the Royal Commission on

REGINALD CHEYNE ELMSLIE

Workmen's Compensation. Elmslie was one of the little band that gathered around Sir Robert Jones when the British Orthopaedic Association was founded, and in due course he was elected President. From 1933 until his death he served on the Council of the Royal College of Surgeons, an honor accorded to few orthopaedic surgeons.

This list, from which several important appointments have been omitted, serves to show the remarkable range of the man's interests,—they were the interests of a scholar with an active and receptive mind and an unusual capacity for analyzing all that wide experience and unceasing study had stored in an exceptionally retentive memory. Elmslie might justly be called an authority; his judgment was superb and his opinions almost invariably sound. In the course of one busy morning he has been known to discuss a wide variety of subjects, each topic neatly summarized, old ideas presented in a new light, with every observation revealing how carefully he had thought over the problem.

Yet he was not dogmatic. When dealing with colleagues or an opponent in debate he could be, and often was, devastatingly direct and uncompromising; but with any man who showed keen interest in a subject or brought out something new, he was instantly sympathetic and ready to listen, and generous in his acknowledgment of whatever was good.

Few British surgeons since Lister have founded schools in the sense of leaving after them a considerable body of disciples of their own training. In the orthopaedic world there have been two notable exceptions, Robert Jones and Elmslie. An astonishing number of his pupils are now orthopaedic surgeons, and the influence of his teaching has permeated nearly every center in the south of England. He was at his best when teaching in "out-patients at Bart's". He would select a few cases for demonstration, sometimes new patients, and examine each methodically and quickly. When a diagnosis had been made he would offer a neat exposition of the condition and perhaps a few words about its treatment, illustrated by little drawings on the blackboard. It was the simplicity of this teaching that made the subject so attractive and stripped it of that aura of mystery that for too long had marked orthopaedic surgery as something beyond the ken of the undergraduate. The same simplicity characterized Elmslie's operating. He knew what he was doing, and what was even more important, he knew why he was doing it. The facility and gentleness that marked his work gave an impression of ease that was deceptive.

As a pioneer, Elmslie was known best perhaps to those concerned with the social aspect of orthopaedic surgery and massage. On the purely surgical side his vision was too wide and his poise too balanced for the pursuit of pet enthusiasms—he saw too many panaceas die in infancy—and he scorned fashions and novelties in his specialty. Nevertheless he substantially advanced the subject by a number of valuable original contributions; he unravelled the varieties of coxa vara at a time when hardly anything was known about this deformity; he brought order out of the pathological chaos that went by the name of fibrocystic disease of bone. In many other conditions he was especially interested, and yet his numerous writings hardly do him justice because they were in no way commensurate with his knowledge. Several excellent operations bear his name, but only among those who knew him for he never published descriptions of them.

At this close range Elmslie's character is a little difficult to assess. The accompanying photograph, a good one taken late in life, suggests an aloofness that might be almost forbidding. Aloof he was; he lived simply; he loved his work; he cared nothing for popularity, and he scorned publicity. He was warm in his friendship, a friendship enjoyed by an ever-widening circle of colleagues and disciples. His conversation ranged over a host of topics and rarely ended without a little story which always began with "I'll tell you something . . ." and never contained a sting. Elmslie was transparently honest; his opinion was uninfluenced by personal considerations; his views about public affairs in relation to orthopaedic surgery were dictated by one ultimate aim—the prevention and the relief of crippling. His advice to a younger man was based solely on what he thought best for him in relation to his ability and his circumstances. This solid reliability, known only to those who took the trouble to discover it, was his greatest quality, and his friends feel acutely the loss of a man whose rectitude was warmed by a kindly humanity that inspired loyalty and affection in those who worked with him.

It was inevitable that a surgeon so passionately devoted to the advancement of orthopaedic surgery, particularly in its institutional and social aspects, should meet with many disappointments. Some of his plans, well and truly laid, never matured, or did so only after almost endless setbacks, and yet he never became cynical. Even when ill health made the day's work increasingly burdensome, he continued his way patiently without neglecting any task to which he had set his hand. Had it not been for his increasing weakness of body, he would have played a decisive part in the reorganization of medical services so urgently demanded by the war. To be barred from this was perhaps his greatest disappointment, for he was above all things anxious to serve his country.

LETTER TO THE EDITOR

NOTE: The growth of a new department of medicine or surgery does not take place according to regular methods of expansion, but is often determined by the influence of personal contacts and centered about the efforts of individuals located in various sections of the country. This results in an irregular distribution which is not recognized until a study of the situation is made. Such a survey indicates the geographical needs for further development of equipment and particularly of personnel. This report is given for those who may have special use for this information.—*The Editor.*

To the Editor:

For a long time I have thought that residents finishing their formal course in orthopaedic surgery should have some guidance in the selection of a place to practice their profession. I am, therefore, submitting some ideas which you may see fit to publish in *The Journal of Bone and Joint Surgery.*

How many people are necessary to support an orthopaedic surgeon in the United States?

The Secretary of the American Board of Orthopaedic Surgery estimates that they have certified about half the orthopaedic surgeons, which would give an estimated total of 1200 orthopaedic surgeons. So then in continental United States (census of 1940) there would be one orthopaedic surgeon to every 110,000 people.

How are these specialists distributed among the states?

Below are the states arranged according to persons per orthopaedic surgeon (000 omitted).

District of Columbia	47	North Dakota	106	Iowa	180
Maryland	56	*General Average*	*110*	Hawaii	184
Washington	57	Wisconsin	111	Florida	187
New York	63	Illinois	115	Indiana	190
Delaware	66	Rhode Island	118	South Carolina	190
California	67	Virginia	120	Maine	210
Nebraska	73	Tennessee	121	Kansas	225
Massachusetts	74	Arizona	124	New Hampshire	245
Ohio	84	Michigan	125	North Carolina	255
Minnesota	85	New Jersey	130	Idaho	260
Montana	90	Oklahoma	130	Texas	288
Oregon	90	West Virginia	135	South Dakota	320
Utah	91	Pennsylvania	137	Alabama	470
Connecticut	95	Louisiana	168	Kentucky	473
Colorado	98	Georgia	173	Arkansas	488
Missouri	105	Vermont	174	Mississippi	1090

There are no orthopaedic surgeons in Nevada, New Mexico, and Wyoming listed in the American Medical Directory.

Thus we see a vast difference in the distribution of orthopaedic surgeons.

Why should there be such a wide disproportion in distribution?

Several factors may contribute and each state should be investigated by the prospective practitioner. The following possible causes should be pointed out:

1. A disproportion in income between various areas. The states with the largest number of orthopaedic surgeons proportionally have the highest incomes, and those with the fewest orthopaedic surgeons have the lowest.

2. Density of population plays a definite part. The states without an orthopaedic surgeon have the fewest people per square mile. Furthermore there are no cities of over 30,000 in these states and only twenty-eight cities have a population of 2500 or more.

3. The importance of a metropolitan center is of great moment. Arizona, with a population about as sparce as that of New Mexico, has two fair-sized cities, and supports three orthopaedic surgeons that I know of, one of whom uses a plane in reaching consultations at outlying points. All cities of 250,000 or more are adequately supplied with orthopaedic surgeons. Five cities of over 100,000 (census of 1930) have no orthopaedic surgeons (Tampa, Florida; Cambridge, Lowell, and Somerville, Massachusetts; and Yonkers, New York). Of these only Tampa and Lowell can be considered remote from large cities. Half of the cities with populations between 50,000 and 100,000 have no resident member of the American Orthopaedic Association or the American Academy of Orthopaedic Surgeons, or Diplomates of the American Board of Orthopaedic Surgery, and might prove fertile fields for younger men. It should be noted, however, that many of these cities are only suburbs of larger cities, and the work flows into the larger city. A city of 30,000, not in a metropolitan area, with a good back country, may form an adequate center for orthopaedic work.

4. Closely related to the last factor is the character of hospital facilities. Many fine hospitals in the smaller cities, I find, are poorly equipped for orthopaedic surgery, and the nursing staffs are unfamiliar with our techniques.

5. Climate undoubtedly influences the choice of some men.

6. The presence of institutions—medical schools and clinics—is likely to draw men to communities that are intrinsically unimportant, such as Iowa City, Iowa, and Rochester, Minnesota.

7. A study of the ratio between orthopaedic surgeons and medical practitioners reveals a national average of 1:144. The number of general practitioners to each orthopaedic surgeon in individual states is as follows:

Washington	70	West Virginia	130	North Carolina	190
Delaware	81	Oklahoma	131	Hawaii	205
Minnesota	85	South Carolina	135	Florida	207
North Dakota	85	District of Columbia	138	Idaho	213
Montana	87	Connecticut	139	Iowa	221
Maryland	88	Arizona	140	Indiana	226
Utah	94	*General Average*	*144*	Texas	242
Nebraska	95	Michigan	146	Maine	246
California	109	Missouri	147	Vermont	250
Ohio	111	Georgia	153	New Hampshire	328
Oregon	114	Rhode Island	156	Alabama	348
Tennessee	121	Colorado	160	Kentucky	460
New York	122	Kansas	164	Arkansas	462
Wisconsin	122	New Jersey	169	Mississippi	747
Virginia	128	Illinois	175	Louisiana	169
Massachusetts	129	Pennsylvania	183	South Dakota	267

There are no orthopaedic surgeons for Nevada, New Mexico, and Wyoming listed in the American Medical Directory.

A high ratio combined with a large population per practitioner would indicate either a relatively poor population, a very healthy area, or one in which reference work was uncommon. One might check any specific area against a more established specialty such as ophthalmology or otolaryngology.

The young man should ask concerning the near future of any area. At present our institutions are training about eighty men a year capable of qualifying for the certificate of the American Board of Orthopaedic Surgery. The average age for beginning practice is thirty years. The average age of retirement or death is about sixty-four years. Assuming that there are no radical changes in birth, death, and immigration rates, in thirty

years this country will have a population in the neighborhood of 155,000,000. Assuming similar factors about orthopaedic surgeons, we shall have by 1970 about 2600 orthopaedic surgeons; or one to every 58,000 population, about twice as many as exist today. This would place the whole country in the overcrowded condition of California and the other states at the top of the list.

With this as a prospect for the future, what other factors should be investigated?

1. What is included in the subject of orthopaedic surgery by the men of the proposed community?

The limitation of orthopaedic surgery to deformities and disabling motor diseases, with the elimination of traumatic conditions, would cut the required orthopaedic surgeons to about 10 per cent. of the present number. The inclusion of traumatic surgery brings one into competition with general and industrial surgeons, and with many general practitioners. Pioneering in a smaller community remote from a metropolitan area is likely to be a Herculean task.

2. One should consider the commercial geography of the location. A highway and railroad center would be better than a town just on the road.

3. An investigation should be made of the group of orthopaedic surgeons in the particular community that one is interested in. Let us compare two saturated areas, Metropolitan Los Angeles and the San Francisco Bay area. There are about 50,000 persons per orthopaedic surgeon in the former and 40,000 in the latter area. Breaking the orthopaedists into age groups one finds 40 per cent. of the San Francisco men are beyond fifty years of age while only about 20 per cent. of the Los Angeles group are that old. Nearly half the men in Los Angeles and less than 20 per cent. in the San Francisco area are under forty. Apparently San Francisco could stand some new blood sooner than Los Angeles, but neither area can stand any more orthopaedic surgeons at present. If none came for fifteen years conditions would tend to improve for all. If any community should suddenly exhibit a phenomenal growth, prospects might be radically altered.

The study suggests that our national Associations should try to prevent the glutting of the market for the sake of cheap help, as occurred in the nursing profession a decade or more ago.

The use of the directory of the American Board of Orthopaedic Surgery, the American Medical Directory, the World Almanac, and a good road map will be of great help in making a satisfactory analysis of a given area. Finally a studious visit to the prospective area would be advisable.

STEELE F. STEWART

3780 Wilshire Boulevard
Los Angeles, California

News Notes

The Ninth Annual Convention of **The American Academy of Orthopaedic Surgeons** will be held in New Orleans, Louisiana, on January 13, 14, 15, and 16, 1941, under the presidency of Dr. Robert D. Schrock of Omaha. The headquarters will be the Hotel Roosevelt.

On Monday morning, January 13, a clinical program will be presented at the Hutchinson Memorial Building, Tulane Medical School, by the local members of the Academy.

The following scientific program has been arranged:

TUESDAY, JANUARY 14

Morning Session

Localized Fibrocystic Disease of Bone.
Rufus H. Alldredge, M.D., New Orleans, Louisiana.
Discussion: Walker E. Swift, M.D., New York, N. Y.
Philip D. Wilson, M.D., New York, N. Y.

Aseptic Necrosis and Bone Drilling.
Ernst Bergmann, M.D., New York, N. Y. (By invitation.)
Arthur Krida, M.D., New York, N. Y.
Discussion: Frank N. Potts, M.D., Buffalo, New York.

Operative Treatment of Legg-Perthes Disease.
Paul B. Steele, M.D., Pittsburgh, Pennsylvania.
Discussion: A. Bruce Gill, M.D., Philadelphia, Pennsylvania.
M. Beckett Howorth, M.D., New York, N. Y.
Charles W. Peabody, M.D., Detroit, Michigan.

Thrombophlebitis and Postphlebitic Oedema.
Alton Ochsner, M.D., New Orleans, Louisiana. (By invitation.)

Congenital Pseudarthrosis.
Harold B. Boyd, M.D., Memphis, Tennessee. (By invitation.)
Discussion: Paul C. Colonna, M.D., Oklahoma City, Oklahoma.

Shelf Operation at the Hip: New Method.
Edwin W. Ryerson, M.D., Chicago, Illinois.
Discussion: Frank D. Dickson, M.D., Kansas City, Missouri.
C. H. Crego, Jr., M.D., St. Louis, Missouri.

An Evaluation of Physiotherapy in Early Treatment of Anterior Poliomyelitis.
H. R. McCarroll, M.D., St. Louis, Missouri.
C. H. Crego, Jr., M.D., St. Louis, Missouri.
Discussion: Oscar L. Miller, M.D., Charlotte, North Carolina.
J. Albert Key, M.D., St. Louis, Missouri.

Afternoon Session

Classification of Bone Tumors According to Radiosensitivity.
Murray Copeland, M.D., Baltimore, Maryland. (By invitation.)

Gradation of Ewing's Tumors.
Willis C. Campbell, M.D., Memphis, Tennessee.
J. F. Hamilton, M.D., Memphis, Tennessee.

Hemangioma of the Vertebra.
R. K. Ghormley, M.D., Rochester, Minnesota.
A. W. Adson, M.D., Rochester, Minnesota.
Discussion of the above three papers:
Robert D. Schrock, M.D., Omaha, Nebraska.
Alan DeForest Smith, M.D., New York, N. Y.

End Results of 200 Cases of Suppurative Arthritis.
John A. Heberling, M.D., Pittsburgh, Pennsylvania.
Discussion: Jacob Kulowski, M.D., St. Joseph, Missouri.
Carl E. Badgley, M.D., Ann Arbor, Michigan.
The Use of Neoarsphenamine in the Treatment of Acute Osteomyelitis with Associated Staphylococcus Septicaemia: A Clinical and Experimental Study.
Edward Le Cocq, M.D., Seattle, Washington.
Discussion: A. R. Shands, Jr., M.D., Wilmington, Delaware.

WEDNESDAY, JANUARY 15

Morning Session

An Accurate Method for the Estimation of the Expected Growth of the Femur and Tibia in Individual Children.
Gerald G. Gill, M.D., San Francisco, California. (By invitation.)
A Study of End Results in Bone-Lengthening.
Beveridge H. Moore, M.D., Chicago, Illinois.
Discussion of the above papers:
LeRoy C. Abbott, M.D., San Francisco, California.
J. Warren White, M.D., Greenville, South Carolina.
The Timing of the Fracture-Healing Process: Its Influence on Choice and Application of Treatment Methods.
Clay Ray Murray, M.D., New York, N. Y.
Discussion: Melvin S. Henderson, M.D., Rochester, Minnesota.
J. Albert Key, M.D., St. Louis, Missouri.
Relationship of the Periosteum to the Repair of Bone.
John R. Moore, M.D., Philadelphia, Pennsylvania.
Dr. Steinbergh, Philadelphia, Pennsylvania.
Discussion: Philip Lewin, M.D., Chicago, Illinois.
Guy W. Leadbetter, M.D., Washington, D. C.
The Fate of Fascia Lata in Knee-Joint Reconstruction: Histological Study.
E. T. Evans, M.D., Minneapolis, Minnesota.
Discussion: Wallace H. Cole, M.D., St. Paul, Minnesota.
Comparison of Stainless Steel and Vitallium as Material for Internal Fixation of Bone.
J. Albert Key, M.D., St. Louis, Missouri.
Discussion: Walter G. Stuck, M.D., San Antonio, Texas.
Use of Vitallium Ferrule to Alleviate Lesions of the Head of the Radius.
Kellogg Speed, M.D., Chicago, Illinois.
Discussion: Harold R. Bohlman, M.D., Baltimore, Maryland.
M. N. Smith-Petersen, M.D., Boston, Massachusetts.
Fracture of the Patella Treated by Removal of the Fragments: End Results.
J. E. M. Thomson, M.D., Lincoln, Nebraska.
Discussion: Edward Harlan Wilson, M.D., Columbus, Ohio.
E. J. Berkheiser, M.D., Chicago, Illinois.
Some Mechanical Derangements of the Knee.
Allen F. Voshell, M.D., Baltimore, Maryland.
Otto C. Brantigan, M.D., Baltimore, Maryland.

Afternoon Session

Organization for Evacuation and Treatment of War Casualties.
N. T. Kirk, M.D., Washington, D. C.
Discussion: Philip D. Wilson, M.D., New York, N. Y.
Harold R. Conn, M.D., Akron, Ohio.
George E. Bennett, M.D., Baltimore, Maryland.
President's Address.
Robert D. Schrock, M.D., Omaha, Nebraska.

Conservative and Operative Treatment of Fractures of the Carpal Scaphoid.
K. O. Haldeman, M.D., San Francisco, California.
Ralph Soto-Hall, M.D., San Francisco, California.
Discussion: E. F. Cave, M.D., Boston, Massachusetts.

Use of Preserved Bone Grafts in Orthopaedic Surgery.
Alberto Inclán, M.D., Havana, Cuba.
Discussion: Fred H. Albee, M.D., New York, N. Y.

Treatment of Calcified Tendinitis.
Joseph E. Milgram, M.D., Brooklyn, New York.

The Public Care of the Physically Handicapped.
Fred H. Albee, M.D., New York, N. Y.

THURSDAY, JANUARY 16

Morning Session

The Rib Joints.
Joel E. Goldthwait, M.D., Boston, Massachusetts.

The Rôle of Curare in the Prevention of Fractures in Convulsive Metrazol and Insulin Shock Therapy.
W. R. Hamsa, M.D., Omaha, Nebraska.
Discussion: M. E. Pusitz, M.D., Topeka, Kansas.
Edgar D. Oppenheimer, M.D., New York, N. Y.

Experimental Studies in the Use of a "U" Clamp for Approximation and Fixation of Spinous Processes in Vertebral Fractures.
Robert V. Funsten, M.D., Charlottesville, Virginia.
Discussion: R. Nelson Hatt, M.D., Springfield, Massachusetts.
Arthur G. Davis, M.D., Erie, Pennsylvania.

Surgery of the Intrinsic Muscles of the Hand Other than Those of Opposition of the Thumb.
Sterling Bunnell, M.D., San Francisco, California.
Discussion: Arthur Steindler, M.D., Iowa City, Iowa.

A New Operation for Acromioclavicular Dislocation.
E. B. Mumford, M.D., Indianapolis, Indiana.

Executive Sessions will be held at noon on Tuesday and at eleven o'clock on Thursday.

Dr. Hugh T. Jones announces the association with him of Dr. John R. Black. Their address is 909 Wilshire Medical Building, 1930 Wilshire Boulevard, Los Angeles, California.

Dr. Philip I. Burack, formerly of Columbus, Ohio, is now located at 1085 Park Avenue, New York City.

Dr. G. Mosser Taylor and his associate, Dr. Alonzo J. Neufeld, have moved their offices to 1216 Wilshire Boulevard, Los Angeles, California.

The 1940 meeting of the **Clinical Orthopaedic Society** was held in Milwaukee, Wisconsin, on October 18, and in Madison, Wisconsin, on October 19. The newly elected officers of the Society are as follows: President, Dr. Fremont A. Chandler; Vice-President, Dr. Herman C. Schumm; Secretary-Treasurer, Dr. Myron O. Henry. The 1941 meeting will be held in Cleveland, Ohio.

The **Orthopaedic Forum** held its Eleventh Annual Meeting in New York on October 24 and 25. The morning of the first day was spent at the Hospital for Joint Diseases and the afternoon at St. Luke's Hospital. The next day was spent at the Mountainside Hospital in Montclair, New Jersey. The attendance at the meeting was 100 per cent.

The Orthopaedic Guild held its Sixth Annual Meeting in New York City on November 1 and 2. The sessions were held at the New York Post-Graduate Medical School and Hospital, and at the New York Orthopaedic Hospital. An interesting program was presented.

The fourth meeting of the orthopaedic society previously known as the Orthopaedic Forum was held in Columbus, Ohio, on Friday, November 22, at the White Cross Hospital. A very interesting program was presented by the host orthopaedic surgeons.

Because the name "Orthopaedic Forum" had been in use for some time by a larger and older organization, it was decided to change the name to the **Tri-State Orthopaedic Society.** The next meeting will be held in April, 1941, in Fort Wayne, Indiana.

The registered attendance at the Sixty-Ninth Annual Meeting of the **American Public Health Association** and meetings of related organizations held in Detroit the week of October 7 was 3,187, second largest in the Association's history. Delegates came from every state in the Union, the District of Columbia, Alaska, Hawaii, Puerto Rico, Canada, Cuba, Mexico, Denmark, China, and New Zealand.

The officers elected for the year 1940–1941 are as follows: President, W. S. Leathers, M.D., Nashville, Tennessee; President-Elect, John L. Rice, M.D., New York, N. Y.; Vice-Presidents, Robert D. Defries, M.D., Toronto, Canada, Charles Edward Finlay, M.D., Havana Cuba, and Selskar Gunn, New York, N. Y.; Treasurer, Louis I. Dublin, Ph.D., New York, N. Y.; Chairman of the Executive Board, Abel Wolman, Dr.Eng., Baltimore, Maryland; and Executive Secretary, Reginald M. Atwater, M.D., New York, N. Y.

A Committee on Public Health in the National Defense was appointed, with W. S. Leathers, M.D., Chairman.

Among the resolutions passed was one emphasizing the necessity for maintaining civilian health as essential in national defense and pledging the united support of members to the national defense and to the maintenance of health in a free people.

The Seventieth Annual Meeting will be held in Atlantic City, New Jersey, in October, 1941.

The **Mississippi Valley Medical Society** offers annually a cash prize of $100.00, a gold medal, and a certificate of award for the best unpublished essay on any subject of general medical interest and practical value to the general practitioner of medicine. Certificates of merit may also be granted to the physicians whose essays are rated second and third best. Contestants must be members of the American Medical Association and residents of the United States. The winner will be invited to present his contribution before the next annual meeting of the Mississippi Valley Medical Society at Cedar Rapids, Iowa, October 1, 2, and 3, 1941. The Society reserves the exclusive right to publish the essay first in its official publication—the Mississippi Valley Medical Journal. Contributions should not exceed 5,000 words, should be typewritten in English in manuscript form, submitted in five copies, and must be received not later than May 1, 1941. Further details may be secured from Harold Swanberg, M.D., Secretary, Mississippi Valley Medical Society, Quincy, Illinois.

Current Literature

BONE GRAFT SURGERY IN DISEASE, INJURY, AND DEFORMITY. By Fred H. Albee, M.D., LL.D., Sc.D., F.A.C.S., F.I.C.S., assisted by Alexander Kushher, M.D., B.Sc. New York, D. Appleton-Century Co., Inc., 1940. $7.50.

This book is such a valuable addition to the bookshelf of any orthopaedic surgeon, that he cannot afford to be without it. The volume is readable and the author's arguments in support of his technique are clear. There are approximately 400 pages, covering the general principles of bone-grafting in nine chapters, and, in addition, an index of authors and subjects. It is the type of book that does not lend itself well to a critical review and must be read to be appreciated.

The author states, "There are incorporated those procedures which have stood the test of time: namely, those which I have used myself and those which I have not elected to use myself but have included because of their employment by experienced surgeons of mature judgment."

Dr. Albee, like all pioneers, is chiefly concerned with proving that a certain procedure is possible. After all, this is as it should be; those who follow the pioneers' methods and techniques ultimately establish or disprove their worth. However, after reading the book, one feels that the author, who has had such a vast experience, should have included another chapter (a short summary, so to speak) which would have dealt with the dangers and pitfalls in bone-graft surgery. It is true that these are mentioned in the text under various headings, but if they had been assembled concisely under one head, it would have been a distinct addition to the book.

The chapter on the general principles of bone-grafting is excellent and the chapter on armamentarium is exceedingly interesting. Few surgeons would have the patience and ingenuity to carry out the many complicated cabinet-making types of procedures for the use of the graft which the author advocates. In discussing the source of the bone for spine fusion, the author claims that, and gives reasons why, the tibia is the source of choice. The author advances the theory that the bone graft in spine fusion probably has a far-reaching effect beyond the mere immobilization, because of the linking up of the circulation of the cancellous tissue in each affected vertebra with that of its neighbor and, through the graft, with that of the healthy vertebrae adjoining the affected area.

The chapter on spine fusion is replete with suggestions of technique original with the author, but he has also included in this chapter the techniques of Hibbs and Girdlestone. His arguments for the use of the bone graft in tuberculosis and scoliosis are far more convincing than those for its use in fractures of the spine.

In fractures of the neck of the femur, Dr. Albee recommends the bone graft for selected cases of fresh fractures, and for all cases of ununited fractures where the capital fragment is of sufficient length to receive it favorably. Some might take exception to the unqualified statement that it is absolutely essential to open all ununited fractures of the neck of the femur and remove the tissue from between the bone fragments. There have already been several series of carefully recorded cases by other surgeons on the use of the bone graft by extra-articular osteosynthetic methods wherein the joint is not opened, and their results compare favorably with those of others using the open method.

The author goes into considerable detail concerning his reconstruction operation for ununited fracture of the neck of the femur, where the non-union has been of long duration and accompanied by much erosion of the capital fragment. This reconstruction operation consists of removing the head of the femur, as in the Whitman procedure, but in addition Dr. Albee provides a bone lever which should be about four inches long, and should protrude laterally, so that the short trochanteric muscles are left intact on the trochanter or proximal end of the lever.

That portion of the book devoted to ununited fractures treated by the aid of the

bone graft is brief, to the point, and clearly advances the author's views. The remaining portion of the book is devoted chiefly to the various uses of the bone graft in rather rare cases, such as the insertion of grafts to take the place of bone tumors that have been removed for malignancy, and loss of bone from other causes. Ingenious methods are advocated for the use of the bone graft to replace bone in congenital absences of bone. The use of the bone graft in plastic operations of the face is also discussed. For the correction of leg inequality, the author cautions that leg-lengthening is at best a hazardous procedure. He describes the operative arrest of growth of the epiphysis by using a bone graft across the line to close the epiphysis. The author's arthrodesing bone-grafting operation for the knee is, in reality, merely an erasion buttressed by two bone grafts. After the knee is prepared, another incision is made over the crest of the tibia to receive the bone grafts. Evidently, Dr. Albee has no fear of contamination of this wound from the one in the knee. To most surgeons, this would seem a definite danger. The author believes that future arthroplasties may be attempted even after arthrodesis for tuberculosis and, therefore, plans his arthrodesing operation accordingly. Arthrodesing bone-grafting operations for the small bones of the foot, ankle, and shoulder are well presented.

This book is filled with interesting material and, backed up as it is by the long experience of a skillful, resourceful, and seasoned orthopaedic surgeon, is particularly valuable. The frequent claims regarding priority, and the use of the personal pronoun are at times a bit irritating, but the fact that this field of surgery has been steadily advancing and has gone far beyond the early dreams of the workers in that field, as mentioned by Dr. H. Winnett Orr in a foreword, is due more to the industry and devotion to its cause of Dr. Albee than to anyone else, and the reviewer would be the last to withhold from him even the least of credit. His work has been an inspiration to all surgeons working in this field and the book places them even further in debt to Dr. Albee.

THE 1940 YEAR BOOK OF INDUSTRIAL AND ORTHOPEDIC SURGERY. Edited by Charles F. Painter, M.D. Chicago, The Year Book Publishers, 1940. $3.00.

The establishment of The Year Book of Industrial and Orthopedic Surgery is evidence of the recognition of the development of this specialty in recent years. Probably no branch of surgery has developed to a greater extent in scope, progress, and the recognition of its importance than traumatic surgery. This development, together with the growth of orthopaedic surgery, has added a large number to those who occupy themselves with these two closely allied subjects. The recent advances in this field have also stimulated interest among a large group of general surgeons, who will welcome the information in the form presented in this volume. With this new addition to their series of Year Books, the publishers have recognized the expansion in these branches of surgery and also the common interest of the orthopaedic and traumatic surgeons. It was a fortunate idea to unite these two divisions of surgery in this presentation, for they form a definite group.

The publishers have been fortunate in obtaining Dr. Painter as editor of this volume. His endorsement and judgment ensure its scientific and practical character.

The status of traumatic and orthopaedic surgery, represented by the present accepted methods of treatment of the more important bone and joint affections, many of which demand major operative procedures, are given in sufficient detail to demonstrate the advances which have been made in recent years. The smaller and less difficult, although perhaps no less important subjects, are presented with the same character and thoroughness, and with sufficient direction for diagnosis and treatment to be helpful to the general surgeon and practitioner.

Orthopaedic surgeons who have kept in touch with the literature will find much of benefit in these reviews which are thorough and clearly expressed, and those who have not been able to follow the recent literature will find the needed information on these special subjects in a form of which they can make practical use. Two hundred and seventy-nine papers have been selected and these are supplemented by 299 illustrations. Opera-

tions, considerations of diagnosis, guides for procedures, and details of techniques which have been employed or described by surgeons of large experience are given special attention.

The scope of the subjects allows an inclusive list of practically all the conditions which come under the care of the orthopaedic and traumatic surgeon. The book is a definite addition to the group of Year Books and the demand for it will certainly ensure its permanency.

SURGERY OF THE HAND. R. M. Handfield-Jones, M.C., M.S., F.R.C.S. Baltimore, The Williams & Wilkins Co., 1940. $4.50.

This book of 140 pages is dedicated to Allen B. Kanavel and to the Casualty House Surgeons, past, present, and future, of St. Mary's Hospital, London. The writer is a great admirer of Kanavel and his works. He feels, however, that Kanavel's book has confused the general practitioner by mixing too much experimental work with the clinical. Handfield-Jones has tried to simplify the subject as much as possible. Great stress has been laid on exact diagnosis, a careful study of the anatomy of the part, and on the principles of treatment.

His general principles of treatment are worth noting:

"1. Never make an incision until the presence of pus is certain.
2. Never make an incision until its exact situation is known.
3. Always operate under full anaesthesia.
4. Always use an air-compression tourniquet.
5. Never make an incision on the dorsum until every other possible site of pus has been eliminated.
6. Always use soft rubber tissue for drainage, never a tube.
7. After forty-eight to seventy-two hours change from hot fomentations to paraffin and flavine dressings.
8. Concentrate upon retention or restoration of full movements.
9. Encourage patient to make movements the hobby of convalescence.
10. When lymphangitis or tenosynovitis is diagnosed, immediately use sulphonamide without waiting for a bacteriological report."

Ninety-five excellent illustrations add to the value of the volume.

KÖRPERLICHE MISSBILDUNGEN (Skeletal Anomalies). Dr. Hellmut Eckhardt. [Handbuch der Erkrankheiten, Band VI, von A. Gütt.] Leipzig, George Thieme, 1940. 24 marks.

This monograph constitutes the second portion of Volume 6 of the Handbook of Hereditary Diseases, published under the editorship of Dr. A. Gütt. The author, in his introductory remarks, notes that where formerly the function of the physician was the care of the individual patient, his present purpose is the improvement of the health of the German people, in accordance with the methods of the National Socialist State.

However, it should not be presumed that the volume contains any therapeutic suggestions. Throughout the volume the author is absorbed in discussing his topics purely with the object of demonstrating the hereditary nature of a number of different conditions. This is not carried out in any critical manner, but mainly by reference to other authors who seem to confirm the theory of inheritance. Where other explanations, such as endocrine imbalance, may be the etiological factor, the author implies that this imbalance is in truth of hereditary origin, and so the matter is again settled. A few typical genealogical charts with circles in black and white complete the proof. What discussion of the mechanism of the inheritance there is, is presented sketchily and by implication.

Apart from this, the monograph presents the subject of dyschondroplasias, osteo-

genesis imperfecta, the syndrome of the mesodermal dystrophies, anomalies of the vertebral column, hands and feet, congenital dislocation of the hips, club-foot, hare-lip, etc., in a pleasing and easily readable manner. The general features of the various conditions are described in broad general terms, so that the relationship between many obscure conditions is more easily comprehended. No therapeutic indications of any kind are given. The references for the discussion of each condition are appended at the end of the volume.

ARTHRITIS AND ALLIED CONDITIONS. Bernard I. Comroe, A.B., M.D., F.A.C.P. Philadelphia, Lea & Febiger, 1940. $8.50.

The book is excellent, concise, carefully edited, and simple. It is designed not only for the general practitioner, but for the specialist who can use it as an authoritative textbook. It covers all the aspects of the arthritic problem, and has an excellent reference system, based on an extensive study of the literature, which is of great service for further study.

Arthritis is a difficult subject to handle, and Dr. Comroe has handled such controversial subjects as classification, the significance of the sedimentation rate, and the differential diagnosis in a clear, practical way by giving the best that is known at the present time. The short summary tables, conspicuously outlined, are excellent. Although the statements are didactic, they serve a purpose and are practical, containing the up-to-date facts.

Such chapters as Chapter Four on Etiology and Chapter Seven on General Treatment are good. Every physician would do well to read and absorb these general ideas of treatment. Chapter Eight on Diet clears the air considerably about this much disputed subject. In Chapter Nine the advice about infection is sound, and the evaluation is important.

Orthopaedic Care of Rheumatoid Arthritis gives the general practitioner a practical working basis, and a picture of what to do and what to keep in mind. The point of view taken about the treatments by iontophoresis, vaccines, sulphur, gold, and other drugs are of real value. There are chapters on gout, backache, bursitis, sciatica, gonorrhoea, fibrositis, even flat feet and tumors, all of which, though not arthritis, confuse the picture and make diagnosis difficult.

The book is well written, easily read, and well put together. It is primarily a textbook and a compilation. The purpose of the book, in trying to evaluate practical methods of treatment from the enormous amount of literature which has been written of late, is well carried out. The author has succeeded in eliminating himself from the book and writes impersonally as a collector and critic. The illustrations are well chosen. The book should serve a very useful purpose, and it is well worth owning.

FRACTURES AND DISLOCATIONS FOR PRACTITIONERS. Edwin O. Geckeler, M.D. Ed. 2. Baltimore, The Williams & Wilkins Co., 1940. $4.00.

This book is a second revised edition of the foolproof procedures for practitioners which appeared three years ago. In its 307 pages, there are 267 figures, including 131 roentgenograms. There is described at least one reliable method of treatment for each fracture or dislocation that a practitioner is apt to meet in any busy accident service. Special emphasis has been placed on the use of skeletal traction and the treatment of compound fractures. The value of follow-up treatment is discussed.

Since the appearance of the first edition three years ago, there has been considerable progress in traumatic surgery due to a number of factors, among which are the ever-increasing number of automobile accidents, and the expansion of industrial accident clinics. The new edition has taken note of these changes, enlarging certain subjects to keep abreast of the latest advances, and adding a total of seventy photographs and roentgenograms. Adequate references to articles and books are listed at the conclusion of each subject.

Many of the subjects are well done; others are rather brief and sketchy. But on the whole, the edition does rather well what the author intended it should,—lead the practitioner along one safe path in the treatment of the fracture which suddenly confronts him, without a confusing wealth of detail. The book is not unlike that which any of us might write, should we record fairly briefly those fracture procedures which in our experience have proved most valuable. Perhaps its greatest worth lies in its simplicity.

THE INJURED BACK AND ITS TREATMENT. Edited by John D. Ellis, M.D. Springfield, Illinois, Charles C. Thomas, 1940. $5.50.

This collection of nine monographs on the management of back injuries is an authoritative discussion by authors well qualified to deal with the problems.

The background for consideration of the clinical discussions is well laid in the articles on Man's Posture by Sir Arthur Keith, and on Routine Examination of the Injured Back by John D. Ellis. The chapter on Backache: A Symptom of Visceral Disease by Nathan S. Davis covers all the conditions that have any spinal reference. The Neurosurgical Aspects of Injuries to the Back by Loyal Davis and Hale Haven is a particularly helpful guide to the indications for treatment where the cord is involved. The other chapters, on Faulty Body Mechanics and Back Injuries; Compressed Fractures of the Vertebral Bodies without Cord Injury; the Rôle of the Articular Facets in Low Back Pain; Relation of Trauma to Certain Inflammatory, Degenerative Diseases, and Anomalies of the Spine; and The Treatment of Minor Injuries, deal interestingly with those phases of the management of spinal injuries.

This book is a comprehensive discussion of great value to all orthopaedic surgeons.

ORTHOPAEDIC SURGERY FOR NURSES, INCLUDING NURSING CARE. Philip Lewin, M.D., F.A.C.S. Ed. 3. Philadelphia, W. B. Saunders Company, 1940. $3.50.

In this, the third edition of Dr. Lewin's recognized book, there are numerous additions to both the text and the illustrations. An attempt is made to cover the entire field of orthopaedic surgery,—a difficult task, to say the least, in a small volume. Considering the scope of the book, the subject matter is well handled, although the author occasionally over-emphasizes the surgeon's problems at the expense of the nurse's duties. It would seem possible that, without enlarging the book, some interesting and helpful discussion of the specific functions of the nurse, in the care of the orthopaedic patient, and directions for her supervision would give added value.

Realizing the great difficulties encountered in writing an abbreviated yet comprehensive text for nurses, the reviewer believes that Dr. Lewin has compiled a very satisfactory book.

TABER'S CYCLOPEDIC MEDICAL DICTIONARY. Clarence Wilbur Taber and Associates. Philadelphia, F. A. Davis Company, 1940. Thumb-indexed, $3.00; Plain, $2.50.

That the value of this work is appreciated is evidenced by its growth from a volume of 607 pages with 20,000 words to this third edition which in 1,500 pages contains between 50,000 and 60,000 words, only a few thousand less than the large unabridged medical dictionaries.

It is a dictionary of medical subject matter as well as of medical terms, and this material is furnished in a book of small, compact, and convenient size. Guides for pronunciation are given by phonetic spelling. Authoritative pronunciation cannot always be found, and, therefore, common usage is followed as much as is feasible. The vocabulary is sufficiently extensive for all practical medical needs, and in addition to the definition of terms, explanation and discussion of many medical subjects are included. Tests are presented in detail and with the standard requirements. The 273 illustrations add greatly to the value of many of the subjects which are discussed.

Some rather radical changes have been made which perhaps will not meet with universal endorsement. In spelling, diphthongs have been eliminated, hyphenated words are indicated as one word, and the letter "k" has been substituted for "c" in many words. These, however, are unimportant details and do not in any way detract from the value of the work.

This book will be found helpful to those who have occasion to look up medical terms with their pronunication and derivation, and also to those who are looking for information on some of the medical subjects. It will be of value and interest to all practicing physicians and surgeons, and almost indispensable to libraries.

STUDIES ON DYSPLASTIC ACETABULA AND CONGENITAL SUBLUXATION OF THE HIP JOINT WITH SPECIAL REFERENCE TO THE COMPLICATION OF OSTEOARTHRITIS. Gunnar Wiberg. *Acta Chirurgica Scandinavica*, LXXXIII, Supplementum LVIII, 1939.

Subluxation of the hip is established as a permanent deformity which may be identified in children by the location of the capital osseus center, dysplasia of this center, and increase in the angle of inclination of the acetabulum. Arthrography with the injection of a contrast medium has permitted a more accurate study of joint details. However, there is difficulty in establishing the diagnosis of subluxation in adults, and the writer offers a method based on the measurement of an angle between a vertical line through the center of the head, and another line through the center of the head and the lateral border of the acetabular roof. An angle of less than 20 degrees indicates defective development.

In following thirty-eight hip joints from childhood to seventeen years of age, the writer found five maldeveloped hips which became normal without treatment. Three hips which had originally been considered normal became defective. Nineteen subluxated hips were followed before and after the development of osteo-arthrosis, and several series of roentgenograms are reproduced. Of the cases of osteo-arthrosis seen over a two-year period, one-fourth appeared to have been due originally to subluxation.

In twenty-eight cases of subluxation which had had shelf operations, one was unimproved, six slightly improved, sixteen considerably improved, and five cured. Two developed osteo-arthrosis in spite of the operation.—*Walter P. Blount, M.D., Milwaukee, Wisconsin.*

EXPERIMENTELLE UNTERSUCHUNGEN ÜBER DIE OSTEOGENESE UND DIE BIOCHEMIE DES FRACTURCALLUS (Experimental Investigation of Osteogenesis and the Biochemistry of Callus). Svante Annersten. *Acta Chirurgica Scandinavia*, LXXXIV, Supplementum LX, 1940.

On the basis of the literature, animal experimentation, and clinical findings, the writer offers a detailed account of the causation of osteogenesis, and the chemistry and mechanism of ossification. He gives up hope of discovering the mechanism of the formation of callus on the basis of morphology. He proves that bone can be formed in normal muscle by the injection of a non-specific, thermostable (up to 78 degrees centigrade) alcohol, ether, or benzol extract of normal bone. This suggests that in the formation of callus the osteogenetic substance as well as the calcium comes from local bone fragments.

The local chemical process of ossification of callus is discussed in detail. In the first few days after the fracture, there is a rapid increase in the phosphorus content of the surrounding musculature. After about seven days the calcium content rises more rapidly than the phosphorus, until the calcium-to-phosphorus ratio of somewhat more than twice that of adult bone is reached. The phosphorus content of blood plasma, unlike the calcium content, increases during callus formation.

The increase of insoluble carbonate comes at a later stage of callus ossification. Increase in bicarbonate appears early, perhaps with a beneficial local alkalizing effect. Hydrogen-ion determinations show that as callus ages, there is an appreciable increase in alkalinity. This alkalinity favors the deposition of tertiary calcium phosphate, and the

activity of phosphatase which is increased in amount in callus.—*Walter P. Blount, M.D., Milwaukee, Wisconsin.*

TRANSITORY SYNOVITIS OF THE HIP JOINT IN CHILDREN. Solomon Rauch. *Am. J. of Diseases of Children*, LIX, 1245, June 1940.

This condition is described as a non-specific, relatively transient inflammation of the synovial membrane of the hip joint of a child. The onset may be acute or insidious, and, clinically, there are symptoms of pain, limp, or unwillingness to walk, and restriction of motion, especially in abduction, extension, and internal rotation. Laboratory evidence of infection, positive tuberculin reaction, and roentgenographic evidence of abnormality are all lacking. The treatment is conservative, and the prognosis for functional recovery excellent. Nearly all recover with two or more weeks in bed.

The author goes thoroughly into the previous literature on the subject, as well as into multitudinous points of differential diagnosis. Forty conditions are listed resembling transitory synovitis of the hip joint, although tuberculous coxitis is given the most emphasis in the discussion.

Thirty-seven case histories are presented in tabular form and various correlations made from the facts. The duration of the condition was from seven to sixty days, with an average of thirty-two days.—*John D. Blair, M.D., Iowa City, Iowa.*

CONDROMIXOOSTEOSARCOMA DELL'ALLUCE (Chondromyxo-osteosarcoma of the Great Toe). Carlo Uggeri. *Annali Italiani di Chirurgia.* XIX, 21, 1940.

A peasant, sixty-seven years old, had noticed for about ten years a painless swelling of his left great toe. Three months before consulting the author a stone he was carrying fell on the toe. The swelling increased and a blue discoloration around the nail remained. He had severe pain which did not subside. About two weeks after the accident an ulceration developed. A disarticulation in the metatarsophalangeal joint was performed. The histological examination showed the interesting feature of a benign chondromyxoma together with some fresh spots of malignant sarcomatous degeneration within the same slide.—*Joseph Wolf, M.D., Davenport, Iowa.*

ANEURISMA CIRSOIDE CONSEGUENTE A TRAUMA (Cirsoid Aneurysm Following Trauma). Carlo Uggeri. *Annali Italiani di Chirurgia.* XIX, 177, 1940.

A case of racemose aneurysm of the left ring finger is described. A man, thirty-four years old, had noticed for twenty-four years that the left ring finger became blue when his hand hung down or was in cold water, and that the discoloration disappeared when the hand was elevated. He also noticed that in summer the volar side of the ring finger perspired more than the other fingers and palm. A year and a half before he was first seen, the tips of four fingers of the left hand were squeezed between a fallen tree and the stump. The pain in the other injured fingers subsided quickly but remained constant in the ring finger where a tumor developed. The examination revealed a tumor with pulsation around the middle phalanx, and the roentgenogram showed partial destruction of the distal end of the first phalanx. The operation and histological examination verified the diagnosis of cirsoid aneurysm.—*Joseph Wolf, M.D., Davenport, Iowa.*

PLASTICHE CON LAMINE DI GOMMA IN LESIONI ARTICOLARI SPERIMENTALI (Plastics with Sheet Rubber in Experimental Articular Lesions). G. Giangrasso. *Annali Italiani di Chirurgia.* XIX, 289, 1940.

The author reports the use of sheet rubber in arthroplastics in a number of experiments on dogs. A material used for this purpose should prevent the proliferation of osseous and periosteal tissue; further the coverage of the raw bone with firm connective

tissue and, thereby, a complete fusion of the covering material with the denuded bone; and finally induce the production of a lubricant having as nearly as possible the qualities of synovial fluid. Sheet rubber, in experiments on the knee joints of dogs. proved to be superior to other media. It is sterilized in distilled water for thirty minutes, boiled a few minutes in a 3-per-cent. phenol solution, and then boiled again in distilled water for fifteen minutes. Sheet rubber gave better results than sponge rubber. It does not irritate the tissues of the joints and in no case was there suppuration or a fistula. For clinical use it proved of value in ankylosis of the mandible. Only fascia lata proved to be of equal value, and it had the additional advantage of more rapidly producing connective tissue to cover the planes of the joint.—*Joseph Wolf, M.D., Davenport, Iowa.*

SULL'ALLUNGAMENTO OPERATIVO DEL FEMORE (Operative Lengthening of the Femur). A. Mezzari and L. Trivelli. *Archivio di Ortopedia.* LV, 452, 1939.

This is a report on eight cases,—seven of tuberculosis of the hip or knee and one of infantile paralysis—in which an operative lengthening of the femur was performed. In tuberculosis the upper third of the femur is the site of the operation; in infantile paralysis the lower third is preferred, since not only a lengthening but a slight posterior angulation at the site of the osteotomy benefits an unstable knee. The patients were between ten and twenty-two years of age, the shortening between 5 and 13 centimeters, the amount of the operative lengthening averaged 4.87 centimeters. Two holes for wires for traction are drilled through the trochanter and the lower metaphysis respectively. A simple oblique osteotomy is preferable to a Z-shaped one. The lengthening is effected by means of progressively increased screw traction starting with 3 to 4 kilograms and increasing up to 20 kilograms after three weeks. In two cases complications—in one infection around the wires, and in the other paralysis of the sciatic nerve—delayed the result which, however, was finally excellent in all cases.—*Joseph Wolf, M.D., Davenport, Iowa.*

SUBLUSSAZIONE ABITUALE DI DIARTROSI FRA I PROCESSI ARTICOLARI DELLE VERTEBRE LOMBARI IV E V (Recurrent Subluxation of the Diarthroses between the Articular Processes of the Fourth and Fifth Lumbar Vertebrae). Camillo Corradi. *Archivio di Ortopedia.* LV, 459, 1939.

A case is described of recurrent subluxation of the right intervertebral joint between the fourth and fifth lumbar vertebrae, in a man thirty-two years of age, following an automobile accident. It was similar to the one described by Hadley in *The Journal of Bone and Joint Surgery* (XVIII, 428, April 1936), except for the fact that the lower articular facet of the fourth lumbar vertebra was dislocated toward the head ("dislocatio cum distractione"), while in Hadley's case the dislocation was in the caudal direction ("dislocatio cum contractione"). The dislocation was marked in roentgenograms taken in a kyphotic position but disappeared with a maximal lumbar lordosis. The diagnosis of this rare dislocation depends on good roentgenograms taken from different angles with the lumbar spine in kyphotic and in lordotic positions.—*Joseph Wolf, M.D., Davenport, Iowa.*

OSTEOCONDRITE DISSECANTE BILATERALE DEL GINOCCHIO (contributo clinico ed istologico) [Bilateral Osteochondritis Dissecans of the Knee Joint (Clinical and Histological Study)]. M. Dragonetti, *Archivio di Ortopedia.* LV, 533, 1939.

To the five cases of bilateral osteochondritis dissecans of the knee joint which so far have been reported in the literature, the author adds the description of a man twenty-four years old. There was no history of trauma, and the destructive process went on over a period of one and one-half years. The roentgenographic appearance was the same on both sides. These facts speak for the theory of the endocrinological etiology of the disease and against that of the traumatic, a question which is still debated in the literature.—*Joseph Wolf, M.D., Davenport, Iowa.*

CONTRIBUTO ALLA CONOSCENZA RADIOLOGICA DELLE ALTERAZIONI DEL TENDINE TERMINALE DEL MUSCOLO SOTTOSCAPOLARE: IL DISTACCO PATOLOGICO DELL'INSERZIONE TROCHINIANA E LA ROTTURA PARZIALE DEL TENDINE OSSIFICATO (Contribution to the Roentgenographic Diagnosis of the Changes in the Tendon of the Subscapularis Muscle: the Pathological Evulsion of the Insertion at the Trochin and Partial Rupture of the Ossified Tendon). Camillo Corradi. *Archivio di Ortopedia.* LV, 545, 1939.

Two rare cases of injuries to the subscapularis tendon are described. A man thirty-two years of age was forming a curve in an iron wire with pliers and rotating his right arm inward when he felt a sudden sharp pain in the shoulder. The roentgenogram showed destruction of the outer upper quadrant of the neck of the humerus and separation of the major tubercle. The destruction of the bone was due to tuberculosis. The author believes his case of pathological evulsion fracture of the major tubercle of the humerus to be the first reported in the literature. The other case is that of a man, forty-eight years of age, who fell from a bicycle on his right shoulder. The clinical and roentgenographic diagnosis was anterior dislocation of the head of the humerus and partial rupture of the ossified tendon of the subscapularis muscle. The author was also unable to find another case of this combination in the literature.—*Joseph Wolf, M.D., Davenport, Iowa.*

INFLUENCE OF FUSION OF THE SPINE ON THE GROWTH OF THE VERTEBRAE. S. L. Haas. *Archives of Surgery,* XLI, 607, Sept. 1940.

In the growing spinal column what happens to the growth when the spinous processes are fused?

With this question in mind, Haas studied the effects of spinal fusions in young dogs. In five instances the spinal fusions were performed by the Hibbs technique, and in twelve by the Albee technique. Modifications of these procedures were used in five other experimental animals.

It was found that the vertebrae continued to grow in length until the fusion became firm. The Hibbs operation, with its mass of soft callus, allowed greater growth than the Albee operation with its fixed graft, but growth continued even after the fusion was solid. However, because the elongation was greater in the anterior part of the bodies of the vertebrae than in the posterior part, a lordosis developed with compression of the intervertebral discs and premature ossification of the epiphyseal cartilaginous plates, particularly near the posterior portions of the bodies. Haas calls attention to the fact that these changes are much more pronounced in dogs than they are likely to be in humans, because the growth of the spinal column is quite rapid in the experimental animal, and is completed in a period of about nine months, while in the human the period of growth may extend from fifteen to twenty years. He offers the hope that the ability to produce deformities by localized fusions may help overcome fixed deformities in the opposite direction.—*I. William Nachlas, M.D., Baltimore, Maryland.*

BACILLUS PYOCYANEUS OSTEOMYELITIS OF THE SPINE. Report of a Case of Successful Treatment with Sulfanilamide. Albert J. Schein. *Archives of Surgery,* XLI, 740, Sept. 1940.

Bacillus pyocyaneus osteomyelitis of the spine is probably very rare. Schein did not know of any cases described in the literature, and, therefore, reports a case that came under his observation.

He calls attention to the fact that occasionally this organism, which is generally only mildly pathogenic, becomes a dangerous invader, particularly after instrumentation of the genito-urinary tract. In the case described, pyocyaneus septicaemia followed a cystoscopic examination. Subsequently, an osteomyelitis of the spine developed and is believed to have been due to the pyocyaneus infection. Immobilization by a plaster

jacket, and sulfanilamide were used in treatment. Apparently the chemotherapy helped in the cure of the patient.—*I. William Nachlas, M.D., Baltimore, Maryland.*

ISCHEMIC CONTRACTURE OF THE LOWER EXTREMITY. Thomas Horwitz. *Archives of Surgery*, XLI, 945, Oct. 1940.

Through the medium of a report of two cases of ischaemic contracture involving the lower extremity, Horwitz calls attention to the fact that Volkmann's contracture can occur in the lower limbs as well as in the upper.

A review of the literature is included and would indicate that relatively few instances of this involvement have been recorded. The etiology is discussed with the apparent conclusion that a venous obstruction is responsible for this complication. Such obstructions could easily be produced in fractures of the lower part of the femur within the popliteal space, where the popliteal vein lies ventral to the soleus muscle, and near the junction of the anterior tibial vein with the posterior tibial vein between the two heads of the tibialis posterior. Though the clinical picture includes, in addition to muscular weakness and deformities of the foot, disturbances of sensation, it is believed that the neurological component is not an essential part of the syndrome. It is suggested that during the acute stage of the injury, which may lead to such complications, fasciotomy should be used. After the deformities have already developed, the usual orthopaedic procedures are helpful.—*I. William Nachlas, M.D., Baltimore, Maryland.*

USE OF THE THIERSCH SKIN GRAFT. B. K. Rank. *The British Medical Journal*, I, 846, 1940.

Statistics on 535 skin grafts, of which 391 were applied to surgically created surface wounds and 144 applied to unhealed or granulated areas, were given. In those applied to surgically treated wounds, a complete "take" was obtained in 83 per cent. In those applied to unhealed or granulated areas a complete take was obtained in only 41 per cent. In the latter group, sepsis was considered the outstanding cause of the poor results. In 72 per cent. of the grafts that failed to "take", sepsis was the cause. Hematomata were the cause of failure in 2 per cent.

Granulating areas are treated with hypertonic saline baths and ultra violet light, and special attention is given to the patient's general condition. In some the granulating surface is removed, and the results are apparently a little better when this is done. Grafts are carefully sutured to the entire wound and pressure dressings are applied. Dressings are not removed for at least seven days. He emphasizes that thinner grafts are more liable to take. Grafts take equally well on all regions except where absolute fixation and firm pressure cannot be obtained.—*Joseph G. Riley, M.D., Boston, Massachusetts.*

TUBERCULOSIS OF THE KNEE. A FOLLOW-UP INVESTIGATION OF OLD CASES. R. C. Murray. *The British Medical Journal*, II, 10, July 6, 1940.

The author reports that in 2,922 cases of bone and joint tuberculosis, knee tuberculosis was found in 11 per cent. of the cases. An investigation of 124 cases, picked at random from this 11 per cent., and all followed for at least five years, was made. Biopsy was not done on any of the cases, and the diagnosis was made purely on clinical evidence. Patients were divided into three groups and treated as follows: (1) Thirty-three with synovial involvement were treated conservatively with a Thomas splint, and 30 per cent. had a full range of motion at the time of collecting the statistics. (2) Seventy patients with focal articular involvement were treated first conservatively and then by excision. The results in this group of cases were ankylosis in 45 per cent. after arthrodesis and in 10 per cent. after conservative care, and the highest mortality,—21 per cent. (3) Seven patients had extra-articular involvement. Five of them healed without inva-

sion of the joint, but in two the joint was affected. One of the conclusions drawn is that "synovial tuberculosis progresses to definite bone changes in 45 per cent. of the cases".—*Joseph G. Riley, M.D., Boston, Massachusetts.*

THE RATIONALE OF COMPLETE IMMOBILIZATION IN TREATMENT OF INFECTED WOUNDS. J. Trueta and J. M. Barnes. *The British Medical Journal*, II, 46, July 13, 1940.

The article is a summary of the available literature dealing with the spread of infection in the body and points out: (1) Bacteria can travel very rapidly from recent wounds to the internal organs; (2) Absorption of bacteria is carried out by blood and lymph streams; and (3) Any measure that reduces the amount of lymph flowing through a limb greatly decreases the chances of absorption of bacteria or their products. It is pointed out that there is no lymph flow from the leg of an animal at rest. It is recommended that wounds be given a thorough excision of the dead or questionable tissue and then receive complete immobilization by means of a plaster cast, which is left on for a relatively long period of time. The conclusion is drawn that it seems best to leave the task of destroying bacteria to the human body.—*Joseph G. Riley, M.D., Boston, Massachusetts.*

MUSCULAR RHEUMATISM. LOCAL INJECTION TREATMENT AS A MEANS OF RAPID RESTORATION OF FUNCTION. Martin Button. *The British Medical Journal*, II, 183, August 10, 1940.

The author uses "muscular rheumatism" to mean stiff neck, lumbago, and "pseudosciatica". A preparation called "novutox" is used, but he believes that any 2-per-cent. mixture of novocain and adrenalin would be equally efficacious. A point at the center of the pain and tenderness is selected and an injection is made one-eighth of an inch beneath the surface of the fascia covering the affected muscle and 2 cubic centimeters are distributed in this area. Patients rest for an hour, and then resume full activity. Specific directions are given for the injection technique for acute and chronic types of nontraumatic rheumatism, as well as for the traumatic type, with illustrations of each type.—*Joseph G. Riley, M.D., Boston, Massachusetts.*

GOLD THERAPY IN RHEUMATOID ARTHRITIS. Philip Ellman; J. Stewart Lawrence; and G. P. Thorold. *The British Medical Journal*, II, 314, Sept. 7, 1940.

Ninety cases of rheumatoid arthritis were divided into three comparable groups. One group of patients were given large doses of gold weekly (.2 or .3 grams). The second group were given small doses (.1 gram) of gold weekly; and the third group, the control group, were given weekly injections of sterile almond oil. (The gold salt used was a British product, "solganal B", and the gold concentration is not given, so comparison with American products is not possible.) Results were judged on the basis of sedimentation rate, circumference of affected joints, clinical appearance of the joints, and roentgenograms. All cases were followed for at least nine months. In 77 per cent. of the group receiving large doses of gold, the sedimentation rate returned to normal. In the group receiving small doses only 37 per cent. became normal, and in the control group, 13 per cent. had a normal sedimentation rate at the end of the experiment. The other indicators of improvement paralleled the sedimentation-rate improvement. Toxic effects were more prevalent in the series receiving large doses, but only rarely were toxic effects seen before the sedimentation rate reached normal. No conclusion is reached concerning the most suitable dosage.—*Joseph G. Riley, M.D., Boston, Massachusetts.*

STUDIES IN EXPERIMENTAL SHOCK. C. H. Best and D. Y. Solandt. *The Canadian Medical Association Journal*, XLIII, 206, 1940.

At the outbreak of the war the authors' attention was directed to the still unsolved problem of traumatic shock, which is certainly one of the major difficulties faced by

military medicine. Their interest has been chiefly in the treatment of the condition, and the present work was undertaken with a view to evaluating certain methods of treating shock in experimental animals. They felt that any procedure useful in severe shock should be initiated by the administration of a vasoconstrictor, temporarily to correct vascular atony so that solutions introduced into the blood stream are not lost immediately into tissue spaces. Concentrated blood serum was chosen for the restoration of blood volume, because it reduces tissue fluids and because it may be kept indefinitely without deterioration, and experimental results indicate that unless the blood pressure is very low pituitrin rather than epinephrine is the better vasoconstrictor to use preceding the administration of concentrated serum. Pituitrin and concentrated serum yielded a relatively prolonged rise in blood pressure, such as was never seen under comparable conditions after the administration of either the concentrated serum or the vasoconstrictor alone. The relative efficacy of serum and of whole blood is at present being determined. The results leave no room for doubt that under the conditions of these experiments the deficiency is largely of protein and fluid rather than of red cells. Their experiments indicate that in traumatic shock at least the injection of a hypertonic fluid is more beneficial than an isotonic one of the same constituents. In shock due to hemorrhage this is probably not true. They believe that the results of these experiments on animals should encourage a further trial of concentrated human blood serum on patients suffering from shock. A project has been started for obtaining and processing large quantities of human blood serum. While the preparation is proceeding at a rather moderate rate, it can be stated that the organization is complete and that it can be readily enlarged in Toronto or duplicated in other centers in Canada, or elsewhere as required.—*F. R. Wilkinson, M.D., Toronto, Ontario.*

THE COMBINED SURGICAL AND FLUOROSCOPIC METHOD OF INSERTING THE SMITH-PETERSEN NAIL. George H. Ryan and Digby Wheeler. *The Canadian Medical Association Journal*, XLIII, 231, 1940.

The authors have attempted to simplify the introduction of the Smith-Petersen nail in the treatment of fractures of the neck of the femur. Their modification has been the use of a stab incision only, without guides, but with fluoroscopic control of the insertion of the guide wire and finally of the nail. The examination of the femoral neck in the lateral view is made by flexing the thigh rather than by moving the tube, or even having a second tube available. They are convinced that a fractured hip may be placed in full flexion without the slightest risk of the displacement recurring, provided that, while the thigh is brought up to 90 degrees' flexion, full internal rotation and full abduction are maintained. Their average operating time for twenty-two cases has been ten and a half minutes.—*F. R. Wilkinson, M.D., Toronto, Ontario.*

FIXATION OF DISLOCATIONS OF THE ACROMIOCLAVICULAR JOINT AND RUPTURE OF THE CORACOCLAVICULAR LIGAMENTS. Gordon Murray. *The Canadian Medical Association Journal*, XLIII, 270, 1940.

Fresh dislocations of the acromioclavicular joint are easily reduced, but the strappings and bandages used to maintain the reduction are usually ineffective. Applying the principle described in an earlier paper on fractures of the clavicle, the author's method is to reduce the dislocation of the acromioclavicular joint, and then pass one or two Kirschner wires through the acromion process across the acromioclavicular joint and into the outer third of the clavicle. It was hoped that, if the joint was maintained in good position by these means, the ends of the ruptured ligaments would lie in apposition and would be in a position to unite and repair. Five cases of this type have been treated in this way with successful results in all. In most cases the wires were removed, as they necessarily passed through some fibers of the origin of the deltoid muscle, and consequently caused some discomfort on abduction of the shoulder. The patients were able to move the arms

about quite freely immediately following the operation, and most of them returned to ordinary desk work within a few days without any other support. Two cases of recent wide dislocation with rupture of the coracoclavicular ligaments were treated with most satisfactory results. Roentgenograms taken later showed extensive calcification of the coracoclavicular ligaments, and gave strong confirmatory evidence that these ligaments had been torn and that they had become repaired. The attractive part of this method of fixation is the ease with which it can be carried out and its effectiveness. It supports the bones adequately and the patient has no discomfort. There is no deformity when the ligaments have become repaired, and there is no disability later on. None of these dislocations has recurred so far.—*F. R. Wilkinson, M.D., Toronto, Ontario.*

THE SURGICAL TREATMENT OF FLAT FEET. Gerald L. Burke. *The Canadian Medical Association Journal*, XLIII, 327, 1940.

The author has recently completed a detailed survey of the end results in 110 patients operated upon for flat feet at the Los Angeles Orthopaedic Hospital. In the majority of these patients Young's modification of Lowman's operation has been done. Young performs a plastic lengthening of the tendo achillis as a preliminary procedure. A drill hole and slot are made vertically through the scaphoid and the tendon of tibialis anterior is pulled posteriorly and placed through the slot into the drill hole. After the operation long leg plaster casts are applied which are removed at the end of seven weeks.

The indications for operation are painful flat feet which have not improved under conservative treatment or which in the surgeon's judgment are unlikely to improve under conservative treatment. The author believes that in general there is a fundamental objection to the fusion of any joint in the surgical treatment of flat feet. The results of operation have been satisfactory to both patients and surgeons in more than 90 per cent. of the whole series.—*F. R. Wilkinson, M.D., Toronto, Ontario.*

A CONTRIBUTION TO THE ANATOMY OF THE ULNAR BURSA. C. R. Salsbury. *The Canadian Medical Association Journal*, XLIII, 430, 1940.

The author has carefully investigated the hands dissected in the anatomy laboratory during the past four years. He found that in 25 per cent. there is no normal communication between the ulnar bursa and the digital sheath of the little finger. In more than 50 per cent. the communication is small and valvelike. In the majority of hands showing no normal communication the two synovial sacs are separated only by a thin septum. Infection of the ulnar bursa is likely to reach the digital sheath by rupture of this membrane. It does not follow, however, that infections of the digital sheath can be easily spread to the ulnar bursa, because the valvelike arrangement of the pointed and invaginated distal end of this bursa may readily close the opening. It is suggested that the production of Kanavel's sign is related to the peculiar anatomical structure of this region.—*F. R. Wilkinson, M.D., Toronto, Ontario.*

OSTEOCONDROSIS DE LA RAMA ISQUIOPUBIANA DEL COXAL (Osteochondrosis of the Ischiopubic Branch of the Hip Bone). Alberto Inclán. *Cirugía Ortopédica y Traumatología* (Habana), VII, 99, 1939.

After commenting on the conception of osteochondrosis in general, the author reviews the literature of ischiopubic osteochondrosis. He has treated many cases of posttraumatic coxitis characterized by pain, claudication, and relative functional restriction of motion in the hip, the symptomatology of which disappears completely after two to three weeks of rest. Some of these cases had been diagnosed elsewhere as coxalgia or Perthes' disease, but the lasting disappearance of the symptoms after some days' rest, ensured the correct diagnosis of ischiopubic osteochondrosis of the growth period.

It was found in the study of 210 roentgenograms that the closure of the ischiopubic epiphyses was complete at the age of seven years, and not, as is pointed out in the textbooks of anatomy and in the medical literature, from eight to ten years. The findings of the roentgenograms are presented in a table. It was also found that in unilateral congenital dislocation of the hip, the closure of the epiphysis in the dislocated hip is delayed, probably due to hypoplasia, as was pointed out by Delitala.

The author stresses that it is necessary to know the course of ossification and its roentgenographic varieties in order to interpret correctly the typical pathological changes of ischiopubic osteochondrosis of the hip bone. In each of the three cases presented the author's criterion, that the bone structure of the ischiopubic branches is altered only when there is some pathological condition at this level, is fully supported. They also show the difficulty of differential diagnosis between this type of osteochondrosis and an inflammatory or infectious pelvic or coxofemoral affection without an x-ray examination.

Though the author does not wish to make any definite statement regarding the etiology of the disease, he believes that trauma is the most frequent source of osteochondritis and osteochondrosis. As in other locations, ischiopubic osteochondrosis is benign, and a cure without deformity is soon obtained by rest and immobilization. The closure of the epiphysis always produces a permanent cure in this form of osteochondrosis.

RADICULALGIAS REBELDES EN ORTOPEDIA (Persistent Radicular Pain in Orthopaedic Conditions). A. Barba Inclán. *Cirugía Ortopédica y Traumatología* (Habana), VII, 124, 1939.

The author presents some observations on persistent radicular pain, or, as its name implies, pain from the spinal nerve roots, due to irritation, compression, or inflammation.

The steadily increasing frequency of this syndrome, its diagnostic as well as prognostic difficulties, its varied and sometimes dangerous treatment, and the infrequency of its incidence in his country, have induced the author to describe four clinical cases treated by him in the National Police Hospital. Three patients had low or sacrolumbar nerve-root pain, and one had pain in the cervical region.

The three cases with low-back pain presented some degree of scoliosis with radiation to the sciatic nerve; one was syphilitic (arachnoiditis), another rheumatic with an evident spondylitis and presumably, also, arachnoiditis, while the third had suffered a traumatic lesion, followed by hypertrophy of the transverse apophysis of the fifth lumbar vertebra and sacro-iliac subluxation.

The fourth case, with radicular pain in the cervical region, presented what appeared to be an infectious arthritis with a possible focus of infection in the vertebrae, but without bone lesions visible in the roentgenograms.

Conservative treatment was employed in all four cases. Besides continuous traction and strict immobilization, medical treatment—injections of patogenol gardier, and the use of salycilate, iodin, sulphur—physiotherapy, and hydrotherapy were also employed. Corrective manipulation without anaesthesia was carried out in the patient with posttraumatic radicular pain.

A great many laboratory tests were carried out. In three cases, the x-ray examination was preceded by a lipiodol injection into the spinal canal.

Though all the patients at present appear cured, there is no assurance that the symptoms will not recur.

ARTROPNEUMORRADIOGRAFIA DE LA RODILLA (Arthropneumoradiography of the Knee). J. I. Tarafa. *Cirugía Ortopédica y Traumatología* (Habana), VIII, 3, 1940.

The injection of contrast media into the joints is indicated in those cases, where an examination of the soft parts within the joint—menisci, capsule, or cruciate ligaments—is desired as well as in the search for foreign bodies, tumors, or other intra-articular changes.

If the meniscus is detached the arthropneumoradiogram will show the penetration of air between the tibial plate and the meniscus; if the meniscus is ruptured the arthropneumoradiogram will show more or less irregular interruptions at the site of the rupture. Tearing off of the cruciate ligaments produces some changes in the normal picture, and is often associated with fracture of the tibial spine. In arthritis there is an enlargement of the capsule and irregularities in its walls. Intra-articular tumors show perfectly defined outlines, while the extra-articular variety squeeze and displace the capsule. Loose bodies in the joint are more clearly seen. In Charcot's knee, besides a marked increase of the joint space and abnormal features of the joint surface, an almost complete destruction of the soft parts is visible.

A Case of Untreated Traumatic Spondylolisthesis of the Third Cervical Vertebra. M. G. Kini and P. Kesavaswami. *The Indian Medical Gazette*, LXXIV, 748, 1939.

The authors report a case of fracture-dislocation of the third cervical vertebra in a man, forty-five years old, who refused surgical treatment. The injury was the result of a fall from a rocking chair when it rocked back too far. The paralysis often associated with such a fracture-dislocation did not occur, and the man complained only of slight rigidity. Roentgenographic examination showed that the body of the third cervical vertebra had slipped forward and the lamina, which was fractured from the body, had remained *in situ*. The case resembled spondylolisthesis due to trauma.

Rôle of Oblique Osteotomy of Upper End of Femur in Hip Joint Surgery. M. G. Kini. *The Indian Medical Gazette*, LXXV, 257, May 1940.

In this article the author discusses derangement of the hip joint, whether due to congenital, traumatic, or pathological causes, and its effect on both locomotion and stability. He tells of his experience with the Lorenz bifurcation in a number of cases, including congenital dislocation, old ununited fractures of the neck of the femur, pathological dislocations of the hip, and osteo-arthritis of the hip. Several of the cases are illustrated by photographs and tracings of roentgenograms. His follow-up of cases in which the oblique osteotomy was performed has convinced the author of the usefulness of this operation.

Plaster-of-Paris. G. R. Girdlestone. *The Lancet*, II, 287, Sept. 7, 1940.

The writer gives clear and concise instruction in the use of plaster-of-Paris. In addition to outlining the proper methods for applying plaster bandage, he describes the cream-fabric method advocated by Trueta for the rapid application of plaster fixation. The pen-and-ink illustrations are helpful, and the article should be invaluable in the training of military surgeons.—*Lenox D. Baker, M.D., Durham, North Carolina.*

Treatment of War Wounds of the Limbs. Experience in 266 Cases. Solly M. Cohen and C. A. R. Schulenburg. *The Lancet*, II, 351, Sept. 21, 1940.

The authors review their experience in assisting with the care of the wounded in the evacuation from Dunkirk and assess the value and dangers of different methods of treatment. All the patients had been wounded at least twenty-four hours earlier and therefore came under the category of "late" cases. The authors condemn the use of local anaesthesia, having found that evipan or pentothal, followed by gas and oxygen, was most satisfactory.

The wound was thoroughly cleansed with ether, soap, and saline. No antiseptics were used. Skin edges were excised, and the wound was laid wide open by radiating incisions without needless sacrifice of skin. Great attention was paid to the fascia as it was

found that, although there was only a small hole in the fascia, there was often extensive disruption of the deeper tissue. To allow adequate drainage, relaxation of the fascia was necessary and was obtained by radiating incisions. No attempt was made to excise or trim muscle or to suture nerves or tendons though the frayed ends of the latter were removed. Only detached fragments of bone were removed. All cases were x-rayed before operation. Large splinters of foreign material were always removed, but no attempt was made to remove the small splinters lying some distance from the entry wound. Subsequently, in a few cases, localized abscess formation around a foreign body necessitated incision. The principle of counter incisions was employed when indicated. Petroleum-jelly gauze from two-inch rolls was used throughout for packing every recess and intermuscular plane. The surrounding skin was coated with a thick layer of petroleum jelly to prevent dermatitis and excoriation. The authors used the closed-plaster method, applying the cast next the skin except for a thin layer of sterilized plaster wool over the wound. Windowing the cast is counselled against because of the development of "window oedema". No prophylactic anti-gas-gangrene serum was given and there was no case of true gas gangrene.

The authors state that the healing of these wounds treated in plaster was astonishing; and they feel that the value of the closed plaster method both for fractures and injuries of the soft tissues is confirmed. The article is well illustrated and the authors' proficiency in the use of plaster-of-Paris is attested to by the photographs.—*Lenox D. Baker, M.D., Durham, North Carolina.*

AN OPERATION FOR ANKYLOSING THE KNEE JOINT. N. D. Royle. *The Medical Journal of Australia*, I, 410, Mar. 23, 1940.

The author states that he has performed this operation in cases of paralytic flail knee for fifteen years and has not had a failure.

The skin and capsular structures are opened by a U incision, the base of which crosses the patella tendon. This is severed, and the patella laid upward. The tibial and femoral surfaces are denuded of cartilage by horizontal sections which give approximation of raw bone surfaces. A vertical anterior sliding graft is then cut from both bones, the longer femoral portion being slid down into the tibia and the shorter tibial portion being placed in the resulting defect in the femur. Union occurs after twelve weeks in plaster, but a knee splint is worn for three more months.

No case reports or statistics are given other than the statement in the first paragraph.—*John D. Blair, M.D., Iowa City, Iowa.*

MORTON'S METATARSALGIA: NEURITIS OF THE FOURTH DIGITAL NERVE. L. O. Betts. *The Medical Journal of Australia*, I, 514, Apr. 13, 1940.

The author gives evidence in this article to support his belief that Morton's metatarsalgia is a neuritis of the fourth digital nerve, with a pronounced neuroma in all cases. He and his colleagues have had nineteen such cases, in all of which the fourth digital nerve was involved, with a definite neuroma in each.

The author postulates the theory that the condition is due to the double origin of the fourth nerve. It is formed by a joining of branches from the external and internal plantar nerves, which come from opposite sides of the belly of the flexor brevis, the nerve thus formed passes forward immediately on the transverse ligament. When the foot is in action the flexor brevis contracts, fixing the origin of the nerve, while dorsiflexion of the toe in walking stretches it around the unyielding transverse ligament. Each of the other digital nerves can slide easily longitudinally as the toes are dorsiflexed. A minor trauma causes the neuritis which progresses because of continued daily irritation.

The author treats the condition by a neurectomy, removing the neuroma and an inch of the nerve through a longitudinal incision between the heads of the third and fourth metatarsals.—*John D. Blair, M.D., Iowa City, Iowa.*

SENILE OSTEOPOROSIS. Ernst Lyon. *Radiologia Clinica*, IX, 89, 1940.

In a discussion of senile osteoporosis, the author states that this disease develops in the entire osseous system, but becomes most evident in the spinal column. The clinical symptoms are lumbago, backache, stitches in the thoracic sides and legs, weakness and exhaustion, decrease in body length, kyphoscoliosis, spontaneous fractures, and bone sensitiveness. Senile osteoporosis develops when bone apposition ceases, while decomposition is normal or increased. The etiological factors consist of polyglandular disturbances, polyhypovitaminosis, heredity, and diet. Consideration should be given to disturbance of liver function in its capacity of transforming provitamin (carotene) into vitamin A. The vitamin-A deficiency in its turn produces osteoporosis. The diagnosis must be differentiated from tuberculosis, osteomalacia, von Recklinghausen's disease, and non-tropical sprue. Treatment consists of the use of vitamins A and D, calcium, adrenalin; mechanical support for the spinal column; and deep irradiation if hypophysial disturbance is considered an exciting cause.—*Frederic W. Ilfeld, M.D., Los Angeles, California.*

LA NÉCESSITE D'HÔPITAUX SPÉCIAUX POUR LES MALADES DE TUBERCULOSE DES OS ET DES ARTICULATIONS (THE NEED FOR HOSPITALS ESPECIALLY EQUIPPED FOR THE TREATMENT OF CASES OF TUBERCULOUS BONES AND JOINTS). Bruno Valentin. *Revista Brasileira de Cirurgia*, February 1939.

The author discusses the need for hospitals especially equipped for the treatment of patients suffering from tuberculosis of the bones and joints. He considers the matter from both practical and theoretical viewpoints, but he stresses chiefly the requirement for special medical care. These patients should be regarded in a category entirely different from the ordinary surgical cases in which the hospital stay is brief, for treatment must be continued for months or years and cannot be accomplished in a general hospital unless there is a department with adequate equipment and facilities for special surgical attention and nursing.

Dr. Valentin considers the effect upon the individual of long continued treatment and the psychological aid which may be rendered by proper surroundings. He cites the value of heliotherapy treatment and discusses the conditions which are found at high altitudes and at the seashore. He also quotes authorities who have realized that special departments should be provided, with modern appliances, and urges that these patients be cared for by those who have had special training in the treatment of bones and joints.

MALFORMATIONS DU SYSTÈME DE L'APPAREIL LOCOMOTEUR (DEFORMITIES OF THE LOCOMOTOR SYSTEM). Bruno Valentin. *Revista Brasileira de Cirurgia*, July 1939.

In classifying deformities, the author states that distinction should be made between a syndrome, deformity of a system (muscles, nerves, etc.), and hereditary deformities. He gives illustrations of cases which have come under his observation, arachnodactylia, cleidocranial dysostosis, pleonosteosis familiaris (Léri), melorheostosis (Léri), and other conditions in which the entire system is involved. In his discussion of each he includes the clinical picture, the hereditary factors, and the still very obscure pathogenesis. Until recently little has been known of the etiology of the diseases mentioned.

ALGUMAS RELAÇÕES ENTRE DOENÇAS DO SISTEMA OSSEO E AS GLANDULAS ENDÓCRINAS (RELATIONSHIPS BETWEEN THE OSSEOUS SYSTEM AND THE ENDOCRINE GLANDS). Bruno Valentin. *Revista Brasileira de Cirurgia*, December 1939.

The author demonstrates that it is not always possible to differentiate disturbances of the glands from their relation to the skeletal system, for the functions of the endocrine glands depend upon the brain which also controls the development of the extremities. He then describes congenital and acquired affections of bones associated with functional

disturbance of the endocrine glands. Hypogenitalism or hypergenitalism may also be a complication in these cases.

From many observations at his clinic, the author arrives at the conclusion that it is not always possible to decide whether a certain affection has its origin in the brain, the glands, or the bones.

DESCOLAMENTO TRAUMATICO DA EPIFISE INFERIOR DO FEMUR (Traumatic Slipping of the Inferior Femoral Epiphysis). Domingos Define. *Revista Brasileira de Orthopedia e Traumatologia*, I, 277, Mar.–Apr. 1940.

The author describes two cases of traumatic slipping of the lower femoral epiphysis with lateral displacement. A statistical analysis of this type of trauma is presented together with a description of the mechanism producing it. An immediate reduction either by open or closed method followed by immobilization is advised.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

SOBRE A FRACTURA ISOLADA DA APOPHYSE EXTERNA DO ASTRAGALO (On an Isolated Fracture of the External Apophysis of the Talus). Achilles de Araujo. *Revista Brasileira de Orthopedia e Traumatologia*, I, 311, Mar.–Apr. 1940.

The author, who found only two recorded cases of this type in the literature, describes his case in detail and gives an analysis of the producing mechanism. The symptomatology of the lesion was pain just below the external malleolus and above the external tubercule of the calcaneum, crepitation at the same level, and fixation of the foot in equinovarus. The treatment consisted in reduction under local anaesthesia, immobilization in plaster-of-Paris for one month, and physiotherapy.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

MEGALODACTYLIAS E MEGALOSYNDACTYLIAS (Megalodactylism and Megalosyndactylism). Achilles de Araujo, *Revista Brasileira de Orthopedia e Traumatologia*, I, 341. May–June 1940.

The author describes a very interesting clinical case of a pregnant woman with a fibroma of the body of the uterus, who gave birth to a boy with a megalosyndactylism of the second and third toes of the right foot. Roentgenograms taken at the eighth month, to clear up the differential diagnosis of twin pregnancy or tumor, showed the anomaly. The observation of the case of megalosyndactylism which ended with a metatarsophalangeal disarticulation is described at length. The author justifies his preference for the term megalosyndactylism instead of macrosyndactylism and describes two personal cases of megalosyndactylism. He gives some consideration to the etiology of such unusual anomalies with special reference to megalosyndactylism.—*Azzi Leal, M.D., São Paulo, Brazil.*

CONSIDERACÕES SOBRE FRACTURAS DA RACHE (Vertebral Fractures). E. Guilherme, *Revista Brasileira de Orthopedia e Traumatologia*, I, 369, May–June 1940.

The author refers to statistics organized by one of his collaborators (Milton Weimberg), which include fractures of the spine observed from the years 1933 to 1936 at the Hospital do Prompto Soccorrodo Rio de Janeiro (Emergency Hospital of Rio), of which the author was the organizer and chief. He considers the spinal fractures from various interesting aspects, among which is that of the careful transportation of patients, every one of whom should be considered, from the practical viewpoint, a latent paraplegic. Dividing the fractures of the vertebral column into two groups, those in which the fractures affect only the bone portions, and those in which there is laceration of the medula as well, the author discusses their treatment and gives some indispensable directions for obtaining the best results from the adopted therapeutic means.—*Azzi Leal, M.D., São Paulo, Brazil.*

FRACTURA MARGINAL POSTERIOR DO PLANALTO TIBIAL (Posterior Marginal Fracture of the Tibial Plateau). Correa do Lago, Jr. *Revista Brasileira de Orthopedia e Traumatologia*, I, 375, May–June 1940.

One case is described, the interest of the description lies in the anatomical and mechanical study of the lesion which is explained by indirect avulsion of the fragment through the cruciate ligament.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

OSTEOMIELITIS CRÓNICA DEL ESTERNÓN; ABSCESO MEDIASTINAL PREPERICÁRDICO, POSTOPERATORIO. CURACIÓN (Chronic Osteomyelitis of the Sternum; Postoperative Prepericardial Mediastinal Abscess. Case with Recovery). Carlos I. Allende, and José P. Traverso. *La Revista de Medicina y Ciencias Afines*, I, 34, 1939.

Osteomyelitis of the sternum is very rare and quite serious, the mortality being nearly 50 per cent. The reason for the high mortality is the fact that a mediastinal infection frequently accompanies the osteomyelitis. The authors present a case in a woman aged twenty-nine years. She had had a fistula of the sternum for ten years which developed gradually. Her presenting symptom was the presence of lumps in the region of both breasts which were felt to be lymph glands. A diagnosis of osteomyelitis of the sternum was made and the patient was operated upon. The operative wound did not heal completely and a small sinus formed which made it necessary to perform an additional operation. At this time a retrosternal prepericardial abscess was encountered and drained. Following this the abscess cavity closed up and stopped draining, and the osteomyelitis cleared up completely, leaving the patient entirely well. A general discussion concerning the pathology, differential diagnosis, and treatment of osteomyelitis of the sternum is given. The article is well illustrated with roentgenograms which show the osteomyelitis of the sternum, and the retrosternal abscess which was visualized by the injection of lipiodol.—*Louis W. Breck, M.D., El Paso, Texas.*

LA OSTEOSÍNTESIS EN LAS FRACTURAS ABIERTAS (Internal Fixation in Open Fractures). R. Paterson-Toledo. *La Revista de Medicina y Ciencias Afines*, I, 44, 1939.

This is a rather academic discussion of operative versus non-operative treatment of fractures and especially of compound, infected fractures. The discussion opens with the presentation of two axioms: Reduction should be anatomically exact, and immobilization should be absolute. Opinions vary considerably as to the importance of anatomical reduction. The English committee for the study of fractures found that 92 per cent. of fractures with good results had exact anatomical reposition, and the author lays great stress on the importance of anatomical reposition. Open reduction is the most certain and satisfactory way of obtaining an anatomically perfect result, and of being sure of complete fixation. On the other hand he points out that many people are opposed to open reduction and prefer closed reduction at all costs. Other forms of treatment such as continuous traction, double-fixed skeletal traction, etc., are used in order to avoid an open reduction. He mentions the advantages and disadvantages of each of these methods. The French school, headed by Lambotte, is quite radical in general, and its members believe that open reduction should be performed in fractures of the shaft of the long bones if there is any doubt about holding the fracture in good anatomical position. Verbugge of Belgium is of practically the same opinion. The Europeans lay great stress on exact anatomical reposition and feel that by obtaining it wound healing in infected fractures is greatly accelerated. The author, after going into considerable detail in the discussion of these methods, states that in his opinion many of the very good statistics concerning open reduction in infected fractures do not stand close scrutiny. He feels that generally speaking it is too dangerous to perform open reductions on already infected fractures and that conservative orthopaedic measures in general will be attended with satisfactory results and a lower mortality.—*Louis W. Breck, M.D., El Paso, Texas.*

RÉSULTATS ÉLOIGNÉS DES MÉNISCECTOMIES (Late Results of Meniscectomies). Vandendorp, Bastien, et Vandecasteele. *Revue d'Orthopédie et de Chirurgie de l'Appareil Moteur*, XXVI, 629, 1939–1940.

The authors review sixty-one meniscectomies, of which three were for cysts of the meniscus and fifty-eight for trauma, from the clinic of Prof. O. Lambret of Lille.

There are difficulties in the proper estimation of late results. If postoperative motion of the knee is considered alone, the late results may give an inaccurate percentage of improvement. It is important to ascertain the amount of residual pain at rest, standing, running, jumping, and kneeling,—activities which are important in certain professions. Two types of operations were used for injuries: the usual parapatellar incision in forty-four cases, and the method of Tavernier, consisting in a horizontal arthrotomy with complete section of the collateral ligament, in fourteen. The postoperative care consisted in a posterior splint for eight days, with walking on the twelfth day in the first type, and a posterior splint for fifteen days with walking on the twentieth day in the Tavernier operation. Of all the cases operated on, estimation of late results could be made in forty-nine, only. Of these a restitution and integrum was obtained in 22.5 per cent., eleven cases; excellent results, consisting in excellent function and absence of pain, except for some pain observed on change of weather, in 42.5 per cent., twenty-one cases; good results—good function but accompanied by pain, especially on kneeling—in 24.5 per cent., twelve cases; mediocre results with limitation of extension and flexion and increased lateral mobility in 10.5 per cent., five cases. Of the twelve observed postoperative results of Tavernier's meniscectomies, two gave complete restitution, five excellent, two good, and three mediocre results. The authors express the view that the results show that the two types of operation are of equal value.

An x-ray study of the postoperative results revealed that the late appearance of deforming arthritis is insignificant, and that the mild articular changes due to the absence of the meniscus are of no practical importance.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

L'OSTÉOCHONDRITE DISSÉQUANTE (Osteochondritis Dissecans). Pierre Ingelrans and E. Laine. *Revue d'Orthopédie et de Chirurgie de l'Appareil Moteur*, XXVI, 645, 1939–1940.

The authors present a short study of the entire problem with an illustrative case report. They advise surgical treatment. In their discussion on the pathogenesis of osteochondritis dissecans, they propose a new theory. Policard has shown that the synovial membrane has the property of cytolysis. It may then be responsible for a separation of a fragment from the surface of bone which undergoes changes of any sort. The elective localization of osteochondritis dissecans in areas which are covered with synovia, the absence of these lesions in areas deprived of the synovial membrane, and, finally, the structure of the deep layer of the foreign bodies, which is very similar to the synovia, all speak in favor of this theory.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

LE TRAITEMENT DES FRACTURES DE GUERRE PAR L'APPAREIL PLATRÉ OCCLUSIF (The Treatment of War Fractures with Closed Plaster-of-Paris Apparatus). G. Baillat. *Revue d'Orthopédie et de Chirurgie de l'Appareil Moteur*, XXVI, 656, 1939–1940.

The author bases his experience mostly on the war casualties in the Spanish war, which were treated in southern France. The urgent and calamitous evacuation of the wounded soldiers and civilians did not permit a proper appreciation of the methods used. Those wounded, who were treated according to the strict rules, as proposed by Trueta, showed remarkable results.

The author describes the principles of treatment of Trueta of Barcelona and the various theories of the mechanics of healing by the closed-plaster method. Like Trueta, the author does not use the preliminary vaselin dressing, as advised by Orr. He con-

cludes that the method, judiciously and correctly applied, would render important service to the war wounded.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

TRATAMIENTO QUIRÚRGICO DE LA LUXACIÓN CONGÉNITA DE LA RÓTULA (Surgical Treatment of Congenital Dislocation of the Patella). Carlos Urrutia U. *Revista de Ortopedia y Traumatología* (Buenos Aires), IX, 203, 1940.

This paper lists operations from the literature and reports thirty observations which were made in the Istituto Rizzoli from its foundation in 1899 until 1937. Various methods were used in these operations. The author gives an extensive list of the operations devised for this condition. Among these are the operations of Albee, Codivilla, Mouchet, and A. Krogius; the U-shaped incision and transposition of the patellar insertion medially, similar to the Jones procedure; and a number of methods less well known. In spite of the great variety of these operations, the end results reported in this series of thirty observations, so far as could be ascertained, were good. There did not seem to be any particular difference between the types of operations, and there is no critical review of the merits of the individual operations in this paper.—*Arthur Steindler, M.D., Iowa City, Iowa.*

LAS FRACTURAS DE LA EMINENCIA CAPITATA DEL HÚMERO (Fractures of the Capitellum of the Humerus). Oscar R. Marottoli. *Revista de Ortopedia y Traumatología* (Buenos Aires), IX, 247, 1940.

This is a rather rare affection. In 1934 Beccari collected forty-two cases. This condition represents a small percentage, about 0.75 of all the lesions of the elbow joint, though Wilson gives a percentage of 1.46.

In the sheer fracture of Mouchet, called décollotement, the fractured fragment carries out a rotary movement forward, for as much as 90 degrees, so that the fracture surface is directed downward; sometimes the rotation is 180 degrees. The fracture is usually caused by a blow or fall upon the extended forearm which is in abduction against the capitulum humeri. The treatment depends entirely upon the condition of the individual case. A number of surgeons believe that it is impossible to reduce the fragments. However, there are reports by Bado, Lagomarsino, and the author, that bloodless reduction, in cases where the rotation of the fragment is less than 90 degrees, is possible. The author reports four cases, in three of which the fragment was removed at operation, and in the fourth, reduction was accomplished, under general anaesthesia with cyclopropane, by manual traction and countertraction, strong ulnar abduction of the forearm, and digital pressure in the external aspect of the joint line. This was followed by immobilization in plaster. Roentgenographic control pictures showed good replacement of the osseous fragment. The plaster was removed after fifteen days, and a splint applied with the arm in 90 degrees' flexion. Ten days later mobilization was begun. After two months the fractured elbow had resumed its normal function.—*Arthur Steindler, M.D., Iowa City, Iowa.*

SPONTANEOUS FRACTURES OF THE SPINE DUE TO DECALCIFICATION. Harry Winkler. *Southern Medicine and Surgery*, CII, 625, Nov. 1940.

The author points out that the adequate human diet requires a definite daily amount of minerals, particularly calcium and phosphorus. In some cases, however, where the intake is sufficient, other factors, such as failure of absorption, may lead to the osteoporosis commonly seen in elderly persons.

Most average American diets lack the proper amount of calcium, and this chronic deficiency in the diet shows up in a greatly decalcified skeleton later on in life.

Deficient hydrochloric acid in the stomach is associated with a decreased ability to

absorb calcium; and the presence of large amounts of fat in the diet inhibits the absorption of calcium by the formation of insoluble calcium soaps. Vitamin D is a decidedly important factor in calcium metabolism and the proper amount is necessary for a normal calcium balance. Glandular changes like parathyroid dysfunction, impairments of kidney function, and changes in the hydrogen-ion concentration of the blood also play an important part in the level of calcium in the blood and thus in the skeleton.

The author reports on a number of fractured spines that occurred spontaneously in elderly people, some of whom were his patients and some of whom had been previously reported by Meulengracht. In one group of six patients spontaneous fractures developed because of the decalcification coincident with a diet very low in calcium content. A second series of eight patients had, in addition to an inadequate diet, a marked gastric achylia. A third group was composed of patients who habitually took cathartics.

These patients complain of pain in the back, may develop a kyphosis, and will lose in height. Roentgenograms will show a marked degree of atrophy, and a biconcave shape to the vertebrae.

Treatment consists in correcting the dietary and absorptive errors, correcting improper intestinal habits, and rest and immobilization or bracing for the spine.—*Herbert E. Hipps, M.D., Marlin, Texas.*

THE USE OF OXYGEN IN JOINTS IN PREVENTING ADHESIONS FROM TRAUMA AND INFECTION. E. Bennette Henson. *Southern Medical Journal*, XXXIII, 776, July 1940.

In acute joints a needle is inserted and as much fluid as possible is withdrawn. Oxygen is then allowed to flow in to the point tolerated by the patient. Compression is made and maintained several minutes at the point where the needle is removed to prevent escape of the oxygen. The patient feels a sense of relief, his apprehension lessens, and voluntary motion is easier. The time of splinting is lessened, and dry joints and adhesions do not occur. No accident of any nature has occurred. This paper is based on a series of 150 cases.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

CHRONIC BACK PAIN WITH SCIATICA. Lawson Thornton and Calvin Sandison. *Southern Medical Journal*, XXXIII, 783, Aug. 1940.

As a general rule one should be conservative in all recent cases of back pain, and surgery should be considered only when enough time has elapsed to prove the condition to be persistent and chronic. In the presence of persistent sciatica, an intraspinal study should be made so as not to overlook a ruptured disc or hypertrophied ligamentum flavum. A method is described, combining exploration of the intraspinal condition, with a spinal fusion, if that is thought necessary. The article is well illustrated.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

LOW BACK PAIN. Paul C. Williams. *Southern Medical Journal*, XXXIII, 788, Aug. 1940.

It has been shown that the lower lumbar and lumbosacral articulations are responsible for symptoms of low-back pain, lumbago, and sciatica in the majority of cases. Changes within the lumbosacral and less frequently other lumbar intervertebral discs are undoubtedly the cause of symptoms in 90 per cent. of those patients who present themselves with any one or all of these complaints. Trauma is the etiological factor in bringing about the changes within the disc in most cases.

Acute traumatic and chronic destruction of the intervertebral disc, and anomalies of the fifth lumbar vertebra and lumbosacral articulations are discussed. The author believes that the insertion of opaque oils into the neural canal to determine disc changes has been abused. Proper x-ray technique and repeated careful clinical examinations afford adequate information for this purpose.

It is the author's opinion that symptoms are due primarily to disturbances in the

mechanics in the lower part of the spine, and that to ignore these and to remove a prolapsed disc will result in persistent local and segmental symptoms following such surgical procedures. All cases should have prolonged conservative treatment before operation, as more than 90 per cent. of these cases can be relieved without surgery. Surgery should relieve nerve-root irritation by removing the facets which correspond to the segmental distribution of pain and nerve changes, and at the same time lay a lumbosacral graft. In those few cases which present spinal fluid changes and symptoms suggestive of a spinal cord tumor, opaque oil in the neural canal is indicated in order to gain a better understanding of the case before surgery is undertaken.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

Fractures of the Neck of the Femur. Jarrell Penn. *Southern Medical Journal*, XXXIII, 798, Aug. 1940.

The author discusses causes of non-union. He favors the introduction of the three-flanged Smith-Petersen nail without the use of guide wires or other gadgets. Two case reports are given,—one a failure with both the Smith-Petersen nail and three Moore pins, and the other a case which healed with a Whitman plaster spica. He concludes that the ultimate solution of fractures of the neck of the femur may not yet have been found, but adequate internal fixation obviates many of the difficulties previously encountered, and apparently is greatly increasing the percentage of good results in these cases.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

A Practical Graphic Method of Recording Leg Length Discrepancies. J. Warren White. *Southern Medical Journal*, XXXIII, 946, Sept. 1940.

The author states that measuring the length of the leg with a tape from the anterior superior spine of the ilium to the internal malleolus is not sufficiently accurate. He places the patient on the x-ray table with both feet pressed evenly against a footboard. A roentgenogram of the pelvis is then made which shows the rounded heads of the femora. A transparent triangular ruler is placed over the roentgenogram and the difference in length is measured. If one leg is too short to reach the footboard, a block of known thickness is placed between the short leg and the footboard.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

Controlled Rotation Osteotomy of the Tibia. D. H. O'Donoghue. *Southern Medical Journal*, XXXIII, 1145, Nov. 1940.

Rotation deformity of the tibia is seen in long standing cases of poliomyelitis and club-foot. The upper end of the tibia is exposed by a four or five-inch incision. The periosteum is incised linearly, medial to the crest of the tibia. The osteotomy is of the Z type. A wedge of bone is removed to allow for rotation. Drill holes are made, and the bones are fastened back together and held by two chromic sutures. The periosteal tube, subcutaneous tissues, and skin are sutured. There is no drain. A plaster cast is applied with knee slightly flexed. A tourniquet is used. The cast is left on for six weeks. Results have been satisfactory.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

Painful Divided Navicular of the Foot. Its Diagnosis and Treatment. John A. Schindler and W. B. Gnagi, Jr. *Surgery*, VII, 133, 1940.

The authors report eight cases of this condition found in the examination of roentgenograms of the feet of 200 unselected individuals. All eight patients gave histories of sprains or fractures of the foot. Three of the five patients who came in complaining of painful feet, had been x-rayed previously.

Diagnosis of the condition is made on: (1) unusual prominence of the mesial portion of the foot and localized tenderness; (2) roentgenograms which show the smooth contour and texture between the navicular and its divided tubercle, and thus distinguish it from

a fracture; and (3) the presence of a similar condition in the other foot, as a divided navicular is a bilateral anomaly.

Treatment is at first conservative, and depends upon the amount of pain. If immobilization fails to stop the pain, the fragment is excised. Three case studies with roentgenograms accompany the article.—*E. F. Thornton, M.D., Iowa City, Iowa.*

THE BIFURCATION OPERATION. Henry Milch. *Surgery*, VIII, 686, Oct. 1940.

Milch reports his observations and results in the use of the bifurcation operation. He mentions as possible objections to the operation, the frequent development of post-operative knock-knee, and the interference with motion, particularly active motion. However, there is a more important objection. Milch states that from his experience the technique, even in the hands of a surgeon who is experienced in and enthusiastic about the method when used in adults, has not been satisfactory when used in children. This less favorable result was produced by absorption of the spike of the distal fragment and changes in the configuration of the femur as the child grew.

As a result of the osseous changes in these children, or for some other unexplained reason, pain and limitation of motion persisted in certain cases as long as the patients were observed.

Milch objected to the spike, which is the essential feature of the bifurcation operation, because he thought that it was one of the principal causes of pain. He found that the excision of this spike, where it had not been absorbed, restored some degree of mobility without loss of stability. It would seem from this article that the author is not particularly enthusiastic about the bifurcation operation, although some of his results were undoubtedly worthwhile.—*E. L. Compere, M.D., Chicago, Illinois.*

THE APOPHYSEAL INTERVERTEBRAL JOINTS. Albert Oppenheimer. *Surgery*, VIII, 699, Oct. 1940.

This is a remarkably thorough study of a little understood skeletal structure, the apophyseal intervertebral joint. The author has dealt with the roentgenographic method, developmental variations and anomalies, arthritis, and trauma, and has correlated symptoms and objective findings in a very excellent report.

He concludes that it is in the apophyseal joints that arthritis of the spine, or spondylarthritis, is localized. Roentgenographic evidence of arthritis should be sought there rather than focusing attention largely or entirely upon the disc synchondrosis, as is so often done.—*E. L. Compere, M.D., Chicago, Illinois.*

CONGENITAL EQUINOVARUS. Lewis Cozen and William Greene. *Western Journal of Surgery, Obstetrics and Gynecology*, XLVIII, 697, Nov. 1940.

This paper presents a survey of eighty-nine cases of congenital equinovarus treated at the Orthopaedic Clinic of the Children's Hospital of Boston from 1929 to 1930, in which a satisfactory correction had been obtained by various methods, both operative and conservative, but in which later developed some degree of recurrence of the deformity.

Improvement of the deformity was obtained by almost any form of treatment, and the final results were generally very satisfactory; however, there was a very marked tendency for the deformity to recur. Shoes were of minor importance in the treatment, and it was felt that too much reliance had been placed in them. It was felt that wedge plaster-of-Paris casts did not offer any advantage over ordinary casts changed at frequent intervals.

Control of the deformity depended to a greater extent upon the continued regular care of the patient than upon any certain form of treatment. No case of recurrence was found wherein a lapse of treatment could not be demonstrated.—*F. Harold Downing, M.D., Fresno, California.*

UNTERSUCHUNGEN ZUR MORPHOLOGIE DER KNIEGELENKSMENISCI AN HAND VON MESSUNGEN UND HISTOLOGISCHEN BEFUNDEN (Morphology of the Menisci of the Knee on the Basis of Measurements and Histologic Findings). G. Schallock. *Virchows Archiv für pathologische Anatomie*, CCCIV, 559, 1939.

The author examined the tendency of slipping of the menisci, in relation to the length, cross section and weight of the meniscus, and finally he tried to find the variation in the histological picture of the menisci. All the measures mentioned were taken into consideration in relationship to the height and weight of the patient. He found that the height and weight of the menisci are proportionate to the height and weight of the patient. Weight-bearing, exceeding the normal duration, leads to changes in the proportions of the menisci. Weight-bearing causes an increase in length and non-weight-bearing causes an increase in width of the mensici.

Fatty and mucous degeneration due to pathological processes have nothing to do with normal conditions.—*T. J. Greteman, M.D., Iowa City, Iowa.*

ALTE BRÜCHE DES NAVICULARE CARPI (OLD FRACTURES OF THE CARPAL SCAPHOID). Hans Virchow. *Virchows Archiv für pathologische Anatomie*, CCCV, 108, 1939.

1. The scaphoid (navicular) consists of two parts, the body and the cones, the latter being distal to the former.

2. The scaphoid has four articulating surfaces: (a) radial, (b) lunar, (c) capitate, and (d) multangular.

3. The cones are covered by periosteum except that part which articulates with the greater multangular. The surfaces between the articulation with the radius and the one with the greater multangular are without cartilage. Dorsiflexion of the hand is accompanied by dorsiflexion of the scaphoid.

4. The kinds of fracture are: (a) fracture of the cones, (b) comminuted fracture, and (c) oblique fracture.

5. The formation of a bone cavity is not the consequence of fracture, but is part of the fracture line which became atrophic.

6. There is a superficial bony plate which after a while bridges the fracture line and covers the marrow cavity.

7. Friction surfaces demonstrate that only flexion motion could take place after the injury.

8. Pseudoarthrosis is possible in any kind of fracture.—
T. J. Greteman, M.D., Iowa City, Iowa.

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Boletines de la Sociedad de Cirugía de Rosario (Argentina), VI, Nos. 5–7, 1940.
Boletines y Trabajos de la Sociedad de Cirugía de Córdoba (Argentina), I, Nos. 4–6, 1940.
Bulletin of the Hospital for Joint Diseases (New York), I, No. 3, October 1940.
The Child (Washington, D. C.), Index to Vol. IV, July 1939–June 1940; Vol. V, Nos. 3 and 4, 1940.
Cleveland Clinic Quarterly, VII, No. 4, 1940.
Current Medicine (Los Angeles, Californai), VII, No. 10, 1940.
La Prensa Médica Mexicana (México, D. F.), V, Nos. 7, 9, 11, and 12, 1940.
Radiography and Clinical Photography (Rochester, New York), XVI, No. 2, 1940.
Revista Cubana de Obstetricia y Ginecología (Habana), II, No. 6, 1940.
Roche Review (Nutley, New Jersey), IV, No. 12, 1940; V, Nos. 1–3, 1940.
The Rotarian (Chicago, Illinois), LVII, No. 6, 1940.
United States Public Health Service. Public Health Reports, LV, No. 51, 1940.
Vida Nueva (Habana), XLVI, Nos. 1–5, 1940.